No. 9. — *Preliminary Report on the Echini and Star-fishes dredged in deep water between Cuba and the Florida Reef, by* L. F. de Pourtales, Assist. U. S. Coast Survey; *prepared by* Alexander Agassiz.

(Communicated by Professor B. Peirce, Sup't U. S. Coast Survey.)

I. *Catalogue of the Echini.*

Cidaris annulata Gray, Proc. Zoöl. Soc., 1855.

Syn. Cidaris metularia Lütk. (non Lam.) Bid. til Kunds. om Echin.

Lütken has adopted for the common West India species the name of C. metularia Lam., which he compares carefully with Cidaris tribuloides. It is evident from his descriptions that his C. tribuloides is the Cidaris metularia Lam.; he says himself that he may not have had the true C. tribuloides Lam. From a direct comparison with original specimens of Lamarck of both these species, kindly sent the Museum by Professor Valenciennes, there is no doubt that both C. tribuloides Lam. and Cidaris metularia Lam. inhabit the Red Sea; the latter, however, has a much more extensive range, and occurs as far as the Sandwich Islands, being quite common in the East Indian archipelago. The Cidaris metularia Lam. is also identical with the species which I named Gymnocidaris minor in the Museum Bulletin (1863). Not having at the time had the opportunity of examining series of different ages, I find that the differences which had been considered as specific are simply different stages of growth. I have adopted for our West India species the name given by Gray, satisfied that he possessed, as far as I could judge from his description, specimens of the only littoral species thus far found in the West Indies.

Littoral to 116 fathoms.

Dorocidaris abyssicola A. Ag., nov. gen. et sp.

This species has the general facies of Cidaris hystrix. We find considerable variation in specimens collected in different localities, — valuable, from the number of specimens collected, in determining the nature of individual variation in this genus, and confirming the view to which I had been brought from the study of young Cidaridæ, that the spines, much as they may apparently vary in shape, especially round the mouth, yet present excellent characters not only to distinguish species, but are also useful as a guide in

separating groups of species which are generally found closely allied. From the study of young specimens I have been led to modify the views I had taken of the nature of genera among Cidaridæ, and as the group requires a complete revision, I will not attempt at present to alter the genera proposed in the Bulletin, hoping to make the changes in the general revision of the order. With reference to Orthocidaris, to which this species is temporarily referred, I would mention that, whether valid or not, the name is preoccupied, having been employed by Cotteau a few months before the publication of the Bulletin.* (The same is the case with Temnocidaris.)

Test depressed; the spines are not as distinctly fluted and crenated as in C. hystrix; they are often worn perfectly smooth, and attain their greatest diameter at about one fifth the length of the spine from the base; the milled ring is finely striated, as well as the neck of the spine, which is sharply defined. The mamelon of the primary tubercles is small, deeply cut at its base, high, the mammillary boss not prominent, the scrobicule deeply sunk; the scrobicular circle and interambulacral miliaries being prominently raised, the secondary tubercles of the scrobicular circle are but slightly larger than the miliaries, diminishing regularly in size towards the sutures of the plates, which are clearly and sharply cut; the same is the case with the sutures of the ambulacral plates; each plate carries a larger exterior tubercle with a smaller one nearer the abactinal edge, and sometimes a third and fourth miliary between the two. The poriferous zone is narrow, but slightly undulating and occupying half the ambulacral plate. The sutures of the plates of the abactinal system are marked by distinctly cut lines, instead of the wavy double line characteristic of C. hystrix; the abactinal system is large, the ocular plates heart-shaped, the genital plates irregularly octagonal; the large sides of the plate adjoining the anal system are separated by five long wedge-shaped anal plates, forming the base of the smaller plates of the anal system.

From 40 to 270 fathoms.

Salenocidaris varispina A. Ag., nov. gen. et sp.

The composition of the plates of the anal system in young Echini, explains most unexpectedly the homology of the sub-anal plate of Salenia, and proves, from a different point of view, that the position of the anal opening can in no wise form a guide by which we can determine any geometrical axis of Echini, but that the only part of the abactinal system which has a constant structural relation to the axis is the madreporic body, which

* Dujardin and Hüpé refer its Mediterranean representative to Leiocidaris *Des.* (Phyllacanthus *Br.*), with which it has nothing in common, as the pores are not joined by furrows. I would substitute for Orthocidaris Ag., non Cott. the name Dorocidaris.

at once gives us the key to the position of an anterior and posterior side among Sea-urchins. The correctness of this view is fully maintained from the analysis of the abactinal system of a living Salenia here described, which shows that the sub-anal plate is the homologue of the first anal plate of young Echini, (which in many cases remains decidedly larger in older stages, — Toreumatica, Genocidaris, Trigonocidaris,) and shows that the abactinal system of Salenia is entirely homologous with the abactinal system of the Echinoids, the original plate only retaining a greater preponderance than has thus far been noticed in other genera. The remaining part of the anal system was, in the fossil species, undoubtedly covered by small plates, as in the living species; and that this was the structure of the anal system is shown by Wright, who has figured the abactinal system of Acrocidaris, and removed the genus to Salenidæ on account of the presence of a sub-anal plate. This feature, which seemed so characteristic of a small group of Echini, is one which alone has no systematic value, so that we must, I think, hereafter consider the Salenidæ simply as a sub-family of Cidaridæ, as the description of the species dredged in Florida by Mr. Pourtales will clearly show.

The general appearance of Salenocidaris is that of a young Dorocidaris abyssicola. The primary spines are enormous, — twice the diameter of the test in length, of a brilliant white color, and of all shapes. Some of them are uniformly tapering, others swelling at about one third the distance from the base, others flattened and curved, but all finely longitudinally serrated with sharp spines, irregularly arranged along the body of the spines. The secondary spines, as well as the greater number of the spines of the ambulacra, as far as the ambitus, are short, club-shaped, sometimes curved and flattened, longitudinally striated with slight serrations. These short spines give to the median interambulacral and ambulacral zone the aspect of the corresponding zones of Cidaris; but they are not, as in Cidaris, arranged in a circle round the base of the primary spines. These small spines, as well as the whole abactinal area, are covered with prominent dark violet pigment cells, standing in striking contrast to the white primary spines. The abactinal system has the structure of that of Salenia, but the position of the anal system is that of Hyposalenia. As we know nothing of the spines of either of these genera, it is better for the present to establish a new genus founded upon this peculiarity of the abactinal system, and the imbricated buccal membrane, which is covered thickly with plates arranged somewhat as they are in Echinocidaris; the ten buccal plates are sparingly covered by pedicellariæ. The primary tubercles of the interambulacral area are large, arranged in two vertical rows in the two areas; those of the ambulacral area are smaller, and diminish rapidly towards the abactinal pole; the median interambulacral space is occupied by two ver-

tical rows of small secondary tubercles. The primary tubercles of both areas are imperforate, but distinctly crenulated. At the actinostome the ambulacra flare slightly, somewhat as in Hemicidaris. The pores are small, placed in pairs far apart, one above the other, so that there seems to be, as far as I could see, but a single pair of pores for each ambulacral plate, though near the mouth they are somewhat closer. As in Salenia, the indentations of the actinostome are very slight. The abactinal system covers nearly the whole of the abactinal part of the test; the anal system is eccentric. There is a marked difference in the size of the genital plates, the three posterior ones being much larger than the two anterior ones; the reverse is the case of the ocular plates. In the largest genital plate there is a trace of the madreporic body, corresponding to the position assigned to it by Forbes, Müller, and Wright, and which cuts the symmetrical axis of the sub-anal plate at an angle; this is the case also with the angle made by the axis of the madreporic body and the first anal plate of young Echini; the position of the axis passing through the anal plate has no definite relation to the madreporic body. The anal opening is covered by small plates, as in other Echini. The whole abactinal system is studded with embryonic spines, which are longest along the exterior edge of the abactinal system, thus separating it most distinctly from the test. The sutures between the plates are deeply cut with deep pits at the angles of junction of the genital and sub-anal plate and of the ocular and genital plates. The three larger genital plates have also pits in the middle of their line of junction with the sub-anal plate. The genital openings are large, placed in the middle of the plates.

Off Double Head Shot Key, 315 fathoms.

Diadema antillarum Phil., Wieg. Archiv, 1845.

Syn. Diadema antillarum Lütk., Bid. til Kunds. om Echin.

Littoral to 17 fathoms.

Cænopedina cubensis A. Ag., nov. gen. et sp.

This species is a living representative of the genus Hemipedina of Wright (as emended by Desor, Wright having included in it species of other genera of Pseudodiadematidæ). It differs from its fossil representative by the peculiar arrangement of the pores, which have a tendency to arrange themselves in lateral arcs of three pairs. The general outline of the test is that of Cyphosoma. It has, like Orthopsis, Echinopsis, Hemipedina, perforate tubercles not crenulated. It reminds us of Pseudodiadema in having tubercles nearly of the same size, and has, like Phymosoma, only two rows of tubercles extending from pole to pole, while the

flatness of the abactinal part of the test, and the great development of the abactinal system, remind us of some forms of Hemipedina, as, for instance, Hemipedina Guerangeri Cott. et Trig. The actinal opening is large, with sharp cuts for the passage of long, narrow gills. The spines are long, moderately stout, as long as the diameter of the test, longitudinally striated, resembling the spines of some species of Hemipedina figured by Wright. The pores are arranged in connected vertical arcs, of three to four pairs. There are two rows of perforate primary tubercles in the ambulacral area, decreasing rapidly in size towards apex, and placed close together. They are somewhat smaller than those of the interambulacral area. There are one or two small imperforate tubercles at the base of the larger ones. The poriferous zone is broad and well defined, spreading slightly at actinostome. The perforate interambulacral tubercles are arranged in two primary rows, separated from the poriferous zone by a row of small imperforate tubercles, with two or three similar irregular rows between the larger tubercles in the median interambulacral zone. The plates of the abactinal system are large, with straight sides, the genital are heptagonal, carrying five to six small tubercles, and as many still smaller ones. The ocular plates are pentagonal, with a large ocular pore surrounded by an arc of small tubercles. The plates covering the large anal system are very numerous and minute. The anus is situated in the very centre. The teeth resemble those of Echinocidaris. The buccal membrane is strengthened round the mouth, close to the teeth, by ten large plates (perforated for buccal tentacles), occupying nearly the whole membrane, with eight to ten very much smaller ones between the large plates and test. The color of the large spines is of a dull yellowish green, while the smaller spines, as well as test and abactinal plates, have a more yellowish tint.

From 138 to 270 fathoms.

Echinocidaris punctulata Desml., Étud. Echin.

Syn. Echinocidaris punctulata A. Ag., Bull. M. C. Z., No. 2.
" " Davisii A. Ag. " " "
" " punctulata Lütk., Bid. til Kunds. om Echin.
" " " " Holmes, P. F. Pl. 2, fig. 5.
Anapesus carolinus Holmes, P. P. F. Pl. 2, fig. 2.

The specimens collected by Mr. Pourtales seem to show conclusively that the species distinguished as E. Davisii in the second number of this Bulletin is only a local variety. All Echinocidaridæ are difficult to distinguish, as there is great variation in the same species, in the number and arrangement of the tubercles; and the characters by which E. Davisii was separated from E. punctulata are found in the large series of young speci-

mens collected by Mr. Pourtales at Cape Fear, North Carolina, to have no permanence. Lütken considers the Echinocidaris pustulosa Lam. as a nominal species; quite a number of specimens of it were brought home by the Thayer Expedition from Brazil. It may be that a larger series than we possess will prove its identity with E. punctulata, but from the material at hand I should consider it a good species, closely allied to E. æquituberculata. I am inclined to think that the various West Coast species of this genus will be limited to two, or at the utmost three, species; namely, E. stellata and E. nigra, perhaps E. spatuligera.

Littoral to 125 fathoms.

Podocidaris sculpta A. Ag., nov. gen. et sp.

This genus has the general facies of young Echinocidaris, with a depressed abactinal surface as in Astropyga, the ambulacra rising in ridges above the surface. The large spines are confined to the lower surface, the primary tubercles scarcely extending beyond the ambitus. These tubercles alone carry a large, smooth mamelon, while the rest of the test is covered with rudimentary spines, arranged, however, in regular, vertical rows, four of which form a distinct, raised band in the median interambulacral zone, flanked by three more, less well defined, while in the narrow ambulacral zone there are but two such rows, close to the poriferous zone, which is very narrow, the pores being arranged in a single vertical row. The rudimentary, knob-shaped spines, strongly serrate, are not carried upon a mamelon, but rise directly from the test, as in very young Sea-urchins, and are connected at their base by a ridge, leaving thus a more or less quadrangular pit in the space between four tubercles. This ridge is particularly prominent between the spines of the median interambulacral rows, while in the more irregular rows the ridges are less marked, forming simply depressions in the test, running irregularly. The pits in the ambulacral zone are very marked, and are connected into an irregular groove extending along the whole ambulacral zone, the ridges, starting from the base of the tubercles, extending only part way across the ambulacral area, like spurs and rounded knobs. The whole surface of the test is covered with long-stemmed, articulated pedicellariæ, which have a distinct mamelon for their support, surrounded by a sort of scrobicular circle, the base of the pedicellariæ forming a ball-and-socket joint with the tubercle, while there is a thin muscular membrane holding them in place, as in true spines, — an additional proof that pedicellariæ are only modified spines, as was made probable by their identical mode of development with spines, observed in the Star-fishes and Spatangoids. The abactinal system, placed in a depression of the abactinal part of the test, resembles that of Echinocidaris, having only four anal

plates, with large genital and ocular plates, which, however, are not bare as in that genus, but carry small, rudimentary, knob-shaped spines. The genital openings are near the anal system. The buccal membrane carries ten large quadrangular plates, with rounded edges placed near the test, the whole space between them and the mouth being covered by small plates; the rest of the membrane is bare. The actinal opening is large, the cuts slight, and the pores are not arranged in ares near the mouth as in Echinocidaris. The spines are sharp, flat spindle-shaped, with a prominent ridge running along the middle of the upper surface, the section is triangular, the longest side being the under side, which is convex, the shorter upper sides being concave. The spines are finely granulated longitudinally with a slightly serrate edge. The large spines, as well as the knobs of the rudimentary spines, are sometimes beautifully colored by dark violet pigment cells, following the arrangement of the granulation. The pedicellariæ have the same coloration. The tentacles, to judge from alcoholic specimens, must have been very large, though not possessed of a powerful disk; the test, when prepared to show the structure, was of a delicate cream color, upon which the brilliant coloration of the knob-shaped spines stood out in bold relief.

From 138 to 315 fathoms.

Echinometra Michelini Des., Agass. Cat. Rais.

Syn. Echinometra Michelini A. Ag. (non. Lütk.) Bull. Mus. C. Z., No. 2.
Echinometra lucunter Lütk., Bid. (non. Lam.)
" lobata Blain., Article Oursin.
Heliocidaris mexicana Auct. (non. Ag.)
Heliocidaris Castelnaudi Hupé in Casteln.

From an examination of typical specimens of Echinometra lucunter Lam. it became evident that Lamarck's species was the common Echinometra, having such an extensive range in the Pacific and Indian Oceans; extending from the Sandwich Islands to the Red Sea. It is with some doubt, however, that the above name has been adopted for our common West India species, the varieties of which have served as the type of many species; the large, somewhat oblong, swollen-sided adult, with short stout spines, has been the Echinometra lobata Blain., the flatter, more circular variety, with long slender spines, has even been referred to a different genus Heliocidaris by Hupé. Authors generally have referred the young flat stage to Heliocidaris mexicana Ag. It is somewhat remarkable that with the extensive geographical distribution of this species (the whole coast of Brazil, the Gulf of Mexico, Caribbean Sea, West India Islands, Bahamas, and Bermudas) it should be so limited in bathymetrical range.

Littoral, to 6 to 7 fathoms.

Note.—Verrill has insisted, in his notes on Radiata, on referring Heliocidaris mexicana Ag. to Anthocidaris Lütk., while he places Toxocidaris mexicana A. Ag. in Toxopneustes; I do not see upon what grounds. The specimens in the Natural History Society of Boston to which he refers are only one of the younger stages of the long-spined variety of Echinometra Michelini Des. (A. Ag.), and have nothing in common with Heliocidaris. In the second place, Anthocidaris Lütk. is synonymous with Toxocidaris A. Ag.; so that it is perfectly natural that the two species he quotes should belong to different genera, one being a young Echinometra, the other a true Toxocidaris A. Ag., Anthocidaris Lütk. I cannot see the propriety of the changes made by Verrill in the limitation of Toxopneustes, by substituting Euryechinus for a group of Echini, which are perfectly well known by all writers on Echinoderms as Toxopneustes. For the following reasons it seems to me, even granting all his premises, that the changes he proposes are not warranted. The type of a genus at the time the Monog. d. Echinides was written was never used in the restricted sense now common, but was coextensive with a group of species. When Toxopneustes was first proposed, it was applied to a so-called typical species which future investigations showed did not belong to the genus. The author took the earliest opportunity possible to point out his mistake by substituting for it another type, and giving a description which *applies not only to Toxocidaris as Mr. Verrill would have it, but also to all the species since removed as Sphærechinus by Desor.* Desor, who had edited the Catalogue Raisonné, and probably knew accurately what group of Echini was defined as Toxopneustes, was the first, in his Synopsis, to limit Toxopneustes by removing from it certain species as Sphærechinus, and restrict Toxopneustes to such forms as (T. neglectus) T. drobachiensis Ag., but still including the species which I have since, in the Bulletin of the Museum, separated as Toxocidaris. All these limitations, even were they not accepted, have the priority over a similar limitation which Verrill makes twelve years after a proper limitation of the genus has been recognized, and eighteen years after a mistake (upon which Mr. Verrill bases the whole of his proposed changes) has been corrected by the author himself; nothing, moreover, is gained in accuracy by the change proposed by Verrill, T. tuberculatus being probably only a nominal species, and one concerning which we have, at any rate, no authentic information sufficient to form the basis of a sweeping reform. At the present rate of retrospective application of the laws of priority, we are fast drifting into the most absurd anachronism by applying the present condition of our knowledge of any group to works written twenty or thirty years ago in an entirely different spirit, when the idea of type, genera, etc. had a totally distinct signification from what it has at the present day.

Echinometra viridis A. Ag., Bull. M. C. Z., No. 2.

Syn. Echinometra Michelini Lütk. (non. A. Ag., nec Des.) Bidrag.
" " plana A. Ag., Bull. M. C. Z., No. 2.

As in Echinometra Michelini Des. there is a flat long-spined variety of Echinometra viridis, distinguished formerly as Echinometra plana, but which the full series now in the Museum collection shows decidedly to hold the same relation to E. viridis which Heliocidaris mexicana Auct. holds to E. Michelini.

Same range as former species, much less common.

Echinus gracilis A. Ag., nov. sp.

This species holds an intermediate position between E. Flemingii Ball and E. melo Lam., to both of which it is allied. Like the former, it is subject to great variations in the ratio of the longitudinal and vertical diameter of the test. The primary tubercles are larger than those of E. melo, but smaller than those of E. Flemingii. The spines in the proportion they bear to test are similar to those of E. melo, as well as the general pattern of coloration, consisting of bands of green made up of irregularly shaped lozenges running in vertical rows, diminishing in intensity towards actinostome, the intermediate spaces forming brilliant white or straw-colored bands. In one of these white bands is placed the poriferous zone, and each primary row of tubercles is placed in a similar band. Thus the test is divided into twenty bands alternately green and white; the poriferous zones and two principal rows of tubercles being separated by these dark-green lozenges, giving the test a most graceful pattern of coloration. The shape of the genital plates of the abactinal system, which is compact and circular, is a pointed pentagon somewhat as in E. melo, while in Flemingii they are heptagonal. The anal system is made up of a large number of small plates. The ten large plates of the buccal membrane are quadrangular with rounded corners, carrying stout pedicellariæ similar to those of E. melo. The position and general arrangement of the tubercles is similar to E. melo; the large tubercle is placed in the centre of the interambulacral plate, which carries in addition short horizontal rows of two or three minute tubercles, the row near the horizontal suture being the most prominent. In the ambulacral zone the main tubercle has a similar position; the small tubercles are placed close to the median suture, and form irregular vertical rows. This species attains a considerable size; specimens are in our collection measuring 2.60 inches in diameter, and another 2.75 inches in height, exceeding somewhat the transverse diameter.

From 93 to 200 fathoms.

Echinus Flemingii Ball, Forbes Brit. Starf.

Among the Echini dredged by Mr. Pourtales is a single small specimen which I am unable to distinguish from specimens of the same size of E. Flemingii. It may be that, when more extensive series of the young of E. melo, E. Flemingii, and E. gracilis, described above, have been compared, that we shall find these species to be only local varieties, though I am not inclined, from the material at my command, which is quite ample, to adopt this view, but rather suppose that we have here, side by side, two allied species, one of which has an extensive range. Grube already considers E. melo and E. Flemingii as identical; I suspect he has only found the two species side by side, as they are both known to inhabit the Mediterranean.

In 195 fathoms.

Genocidaris maculata A. Ag., nov. gen. et sp.

This genus is established for a small Sea-urchin, the living representative of Opechinus, which Desor separated from Temnopleurus. The spines resemble in their structure those of Temnopleurus, but are short; the Sea-urchin with its spines resembling a Psammechinus, and having, like it, a large number of tubercles, of nearly uniform size, closely crowded together, but of a peculiar chiselled structure (so that it may be said that this genus is a Psammechinus among Temnopleuridæ), there is one principal row in the ambulacral and interambulacral area larger than the others. The poriferous zone is narrow; the pores are arranged in an unbroken vertical row separated by an arched ridge. The mamelon of the primary tubercles is smooth, imperforate. Near the base of the tubercle the test is ornamented by cuts specially marked near the suture of the plates, and the small tubercles are frequently connected by a ridge with the main tubercles, the ridge forming spokes radiating from a hub, similar to the structure of Glyphocyphus radiatus, and some species of Echinocyphus. The genera Opechinus, Temnotrema, Trigonocidaris, and Genocidaris form a transition between Psammechinus and Temnopleurus. The actinal membrane is bare, with the exception of the ten small circular buccal plates. The actinal opening is not large, with slight indentations; the test is irregularly covered with pedicellariæ, having a blunt head surmounting a long, slender stem, articulating upon a shorter, stout rod. The abactinal system is peculiar, as we find, in the largest specimens even, which appear fully developed, but a single circular plate, slightly conical, occupying nearly the whole anal system, with the exception of a small crescent-shaped slit, covered by four very small plates. The genital plates are large pentagonal, with a deep groove, in which is situated the genital opening, having on the anal edge a

cluster of three or four small tubercles; the ocular plates are also pentagonal, elongated horizontally. The color of the test is greenish (in alcohol), mottled with dark violet patches; the spines are of the same greenish tinge, banded irregularly with reddish, transverse bands. In other specimens we have the same pattern of coloration, in different shades of green, with white spots irregularly scattered over the surface.

From 30 to 160 fathoms.

Trigonocidaris albida A. Ag., nov. gen. et sp.

This genus is allied to Genocidaris. The principal tubercles have the same structure; but, in addition, the whole test is covered by a reticulation of ridges, similar to those of Podocidaris, extending from the base of the different tubercles, both primary and secondary, and uniting them all in a complicated, raised system of network, with irregularly shaped cells, the ridges leaving more or less deep pits, giving the test the appearance of having been gouged out in spots. The spines are long, slender, somewhat transparent, longitudinally striated, with slight, transverse striation. The abactinal system resembles that of Cænopedina, but the anal system is covered by only four triangular plates, one of which is much larger than the others. From the fact that in the youngest specimens examined we find them already, I am tempted to suppose they never increase in number, and remain as they are, as in Echinocidaris. The actinal membrane is, as in Lytechinus, entirely covered by a number of rather large plates irregularly arranged, the ten buccal plates being but slightly larger than the others. The actinal opening is of moderate size, slightly indented; the auricles are exceedingly slender, and disconnected at the extremity. There are but two principal rows of primary tubercles, both in the ambulacral and interambulacral zone, with from five to six minute tubercles seated upon the connecting ridges in the latter zone, and two to three upon each plate in the former. The poriferous zone is narrow; the pores are placed obliquely in an unbroken vertical zone, three to each ambulacral plate, and separated by ridges running from the ambulacral tubercles to the interambulacral zone, similar to those joining the tubercles. The test, as well as the spines, are almost white, the latter having only a slight tinge of yellow when largest. The whole test is covered with pedicellariæ, having a sharp-pointed head articulated upon a long, slender thread, seeming scarcely capable of supporting the head.

From 40 to 270 fathoms.

Lytechinus variegatus A. Ag., Bull. M. C. Z., No. 2.

Syn. Lytechinus carolinus Ag., Bull. M. C. Z., No. 2.
" " atlanticus A. Ag. " " "
Echinus variegatus Rav., Cat. Echin. S. C.; P. P. Foss. Pl. 2, fig. 1.
" " variegatus Lam., An. s. V.
Psilechinus variegatus Lütk., Bidrag.
Psammechinus exoletus McCr., Pl. Foss. S. C., Pl. 2, fig. 6.

Soon after the publication of the second number of the Museum Bulletin, Dr. Lütken called my attention to the identity of L. carolinus and L. atlanticus with E. variegatus. The extensive series of this species collected by Professor Agassiz in Brazil, the West India Islands, and dredged by Mr. Pourtales, have satisfied me of the correctness of his view, the variations due to age or locality being astonishing. It has, like the common Echinometra, a great geographical range identical with it, but at the same time has a somewhat more extensive bathymetrical distribution.

Littoral, to 34 fathoms.

Tripneustes ventricosus Ag., Agas. Cat. Rais.

Young specimens of Tripneustes show the correctness of the analysis of the arrangement of the pores made by Dr. Lütken. Each ambulacral plate has only three pairs. The original Heliechinus Gouldii Gir., Proc. Bost. Soc. N. H. 1850, is nothing but a young Tripneustes.

Littoral, to 10 fathoms.

Clypeaster rosaceus Lam., An. s. Vert.

It is quite remarkable that of a species so common as this no young small enough to show any very striking difference from the adult should have been collected, while of nearly all the more common species complete series of all sizes were obtained.

Littoral, to 5 fathoms.

Stolonoclypus prostratus Ag., Bull. M. C. Z., No. 2.

Syn. Clypeaster prostratus Lütk., Bidrag.

This genus is distinguished from the true Clypeaster by the character of the internal pillars connecting the actinal and abactinal part of the test, which is totally different, in all the flat Clypeastroids allied to Clypeaster placunarius Lam., from that of Clypeaster rosaceus Lam., being slender, often needle-shaped points, instead of heavy, solid columns, as in true Clypeaster. Rhaphidoclypus cannot be maintained as an independent genus; it is only the young type of Stolonoclypus which presents some striking peculiarities, and the species upon which the genus was based will probably turn out to

be young specimens of a species of true Stolonoclypus, to judge by analogy with the young of this Florida species, which undergo very great changes during their growth, resembling to such an extent Echinocyamus pusillus LESKE of Europe, that for some time I considered the young as identical with that species.

Littoral to 325 fathoms.

Stolonoclypus Ravenelii A. AG., nov. sp.

The presence of a true Laganum in the West Indies has been often mentioned by various writers on Echinoderms, but it has invariably been presumed to be founded upon mistaken localities (Rumphia Lesueuri) or a confusion with young specimens of Stolonoclypus prostratus. Mr. Pourtales has dredged, from a depth of thirty-four fathoms, a small Clypeastroid of about two inches in length, which has the facies of a Laganum to such an extent that it would pass for one without an examination of the internal structure. The outline is pentagonal, with rounded corners; the pentagon is equilateral, and more regular than in any species of Laganum, the central part of the test rising abruptly from the extremity of the ambulacral rosette. The test has a thick, rounded edge, and it may be that specimens of this species have been collected by those who have referred to the presence of a Laganum in the West India Islands. Hupé speaks of Laganum latissimum as found on the coast of Brazil; it certainly cannot be the Clypeaster latissimus LAM., which Agassiz distinctly says is allied to C. scutiformis, although by mistake it was subsequently referred to Laganum in the Catalogue Raisonné, and which is found in the East Indies. The specimen collected by Mr. Pourtales is evidently the young of a large Stolonoclypus collected by Mr. Ravenel off Charleston Harbor, which, from want of additional material, remained undescribed in the Museum collection. It does not differ in outline (although measuring five and a half inches in length) from the smaller specimen; has the same thick, rounded edge, with abruptly rising test near the extremity of the ambulacral rosette. The rosette is not raised as in other species of Stolonoclypus, but is flush with the rest of the test; the whole lower part of the test is flat, as in Laganum. In the smaller specimen the rosette is harp-shaped, well opened at the extremity, as in Echinarachnius, while in the adult this is the case only in the anterior ambulacrum; the others are brought close together at the extremity. The ambulacral rosette extends to within one third the distance of the apex from the edge. The poriferous zone is much broader than in S. prostratus. The furrows are more numerous and more closely crowded together than in any other species of Stolonoclypus. In the younger specimen the lower surface is covered with spines only upon the interambulacral

area. This is narrow, leaving the broad, bare bands of the ambulacral areas colored light yellow, giving this species a striking appearance. The tubercles of the upper part of the test are quite small, closely crowded together; they increase in size in the interambulacral spaces of the lower surface. The color of the spines is greenish yellow in the smaller, and in the larger specimen the color was duller.

Off Charleston bar; Florida in 34 fathoms.

Mellita testudinata Klein, Nat Disp. Echin.

Syn. Mellita pentapora Lütk., Bid.
Mellita quinquefora Ag., Agass. Cat. Rais.
" ampla Holmes, Rav. Cat.

The large series collected by the Thayer Expedition along the whole coast of Brazil show that this species has a wide geographical range, and is liable to great variations, indicating that the characters which are described as separating M. quinquefora and M. testudinata have no permanent value.

Littoral, to 7 fathoms.

Mellita hexapora Ag., Agass. Cat. Rais.

Syn. Mellita hexapora Lütken, Bid.
" caroliniana Rav., Cat.; Pl. Foss. S. C., Pl. 1, fig. 4.

Littoral, to 270 fathoms.

Encope Michelini Ag., Agass. Cat. Rais.

Syn. Encope Michelini Ag., Bull. M. C. Z., No. 2.
" aberrans Martens, Wieg. Archiv. XXXIII. I. p. 112.

The extensive suite of Encopidæ brought home by the Thayer Expedition from different points of Brazil, and more particularly the series of all sizes of Encope emarginata which the Museum owes to the kindness of Dr. Fritz Müller, of Desterro, has satisfied me that Lütken is correct in uniting under one name, that of E. emarginata, most of the nominal species he mentions (E. Valenciennesii, subclausa, oblonga, E. quinqueloba Esh. and Grube), to which we would add the name given by Béval. E. Griesbachii. E. tetrapora Gmel. must remain doubtful, as the original cannot be found in any Museum. Yet I cannot agree with him in referring to the same species Encope Michelini Ag., in which the position of the apex is totally different from that of any of the other species referred to E. emarginata, as is readily seen by the excellent profile given in Agassiz Mon. d. Sent., Pl. 6ª, fig. 10. Nor can I agree with him in referring to Encope emarginata E. grandis Ag., a species found in the Gulf of California, and Encope

Agassizii Mich., identical with it. There is a second species also found on the West Coast, which Verrill has described as E. occidentalis, and which is identical with Encope tetrapora Ag. non Gmel. From a careful comparison of specimens of E. cyclopora, micropora, and perspectiva, there is no doubt that these are only nominal species, all identical with Verrill's E. occidentalis; and as the name micropora seems to be the most appropriate, it would be the best name to retain.

Littoral to 11 fathoms.

Encope emarginata Ag., Agass. Cat Rais.

Syn. Encope Valenciennesii Ag., Agass. Cat. Rais.
" subclausa " " "
" oblonga " " "
" quinqueloba " " "
" Griesbachii Béval., Acad. de Brux.
" emarginata Lütk., p. p. Bidrag.
Moulinsia cassidulina Ag., Agass. Cat. Rais. (young!)
" " Lütk., Bidrag.

Dr. Lütken, in his discussion of Encope emarginata, has given figures of young Encope after the appearance of the posterior interambulacral lunule. Younger specimens in our collection, before the appearance of this posterior lunule, show that Moulinsia is only a young Encope emarginata. As in my account of young Echini I have given a full description of the changes Encope undergoes during its growth, I will only recall them here to justify the synonymy adopted.

Littoral to 7 fathoms.

Echinoneus semilunaris Lam., An. s. v.

Syn. Echinoneus semilunaris Lütk., Bid.
" elegans A. Ag., Bull. M. C. Z., No 2.

Lütken, like myself, has only been able to recognize one species in the West India Islands. As is well known, the difficulty of distinguishing the species in this genus is very great; the more so, as thus far only tests without spines have been used in the determination of species. Mr. Pourtales has collected one specimen at Carysfort Reef with its spines and tentacles, which gives us the first opportunity of making a direct comparison with specimens from the Sandwich Islands (the true E. cyclostomus) still retaining the anal and buccal membranes. As far as I am able to discriminate between the test of these two species, the Pacific species is remarkable for the narrowness of its poriferous zone, the pores being placed in close contact, separated by a ridge carrying small tubercles, while in the specimens

of E. semilunaris the poriferous zone is much broader. It has also (taking the same point of the test in specimens of the same size) larger tubercles, and a greater number of large, glassy tubercles, while the miliaries are closely crowded together. In E. cyclostomus, on the contrary, the primary tubercles, as well as the glassy tubercles, are, proportionally, much smaller and farther apart, the miliaries being more numerous. From the examination of the alcoholic specimen from Florida, I could not come to any satisfactory conclusion concerning the function of the glassy tubercles; they are not primary tubercles in the course of growth, as they are fully as large, and the primary tubercles, when young, always appear at first as opaque tubercles. They carry no special spines. On living specimens their function will probably be ascertained. Similar glassy tubercles often appear on the edge of very young Clypeastroids (Stolonoclypus prostratus), which disappear in older stages. Desor has given figures of the spines; but in addition to these, the test is thickly covered with stout pedicellariæ carried upon moderate peduncles. The tentacles do not differ (as far as could be judged from this alcoholic specimen, where they still were tolerably expanded) from the tentacles of our ordinary Echini, having prominent suckers. The tentacles retain the same structure from the mouth to the apical system. On the lower surface, especially round the mouth and anal system, the spines are longer and more slender than on the remaining portions of test. The anal system will, I think, furnish good characters for the determination of species, if we can judge from the striking differences the arrangement of the plates of the anal system presents in the two thus far examined. In the Pacific species the anal opening is more pear-shaped; the anus is placed near the blunt end, surrounded by a number of small plates arranged concentrically round it, and extending as a narrow band of small, slender, elongated plates between the single rows of large plates, extending on each side along the other extremity of the anal system. This row of large plates consists of five large plates, diminishing in size from the centre of the row towards either extremity, and carry a few large tubercles bearing spines. In the West India species, on the contrary, the anal system is more elliptical, the anus being placed almost in the centre, surrounded by a smaller number of small plates radiating from it irregularly. The single rows are made up of four plates, leaving a triangular space covered by small plates between them and the anus. The rest of the anal system is covered by much larger polygonal plates than in the Pacific species. The buccal membrane is covered by small quadrangular plates, arranged in rows radiating from the mouth, diminishing in size towards the opening of the mouth placed in the centre of the membrane. The absence of teeth is fully confirmed by an examination of this specimen. The close structural resemblance between the young of Echinolampadæ and Echino-

neus shows that Echinoneus has no affinity whatever with the Galeritidæ, with which the genus has always been associated, but that it is a true embryonic Cassidulus allied to Echinolampadæ and Caratomus, already suggested by Desor to be a true Cassidulus, and not a Galerites. This affinity the examination of young Echinolampadæ proves undoubtedly. The removal of Echinoneus, Caratomus, and all the allied edentate forms of Galerites now reduces the family to one of great homogeneity, and suggests again the question of their affinity to true, regular Echinoids in a more forcible manner than before. We must, however, wait till we find a living representative of Galerites, to have the question fully decided. I am inclined, in the mean while, to associate the Galeritidæ having teeth with the true Echinoids, and consider them as forming among Echinoids a prophetic type of the Clypeastroids, with which they have many points of resemblance.

Littoral.

Echinolampas caratomoides A. Ag., nov. sp.

Fragments of an Echinolampas were dredged in the first expedition, indicating the presence of a species which must attain a length of at least two inches. In the second expedition an entire specimen, measuring a little over an inch, was dredged from a depth of thirty-five fathoms. It resembles in outline E. Richardii Desml. found in Senegal, but differs from it by the peculiar structure of the ambulacral rosette, which is not strictly petaloid (the large fragments have the same structure), the two lines of pores of each ambulacrum having a different development. In the posterior pair, the anterior zone is fully developed, forming one side of the petal, while the other zone is not quite half as long. It is the same with the anterior pair of ambulacra, but the anterior zone is the shorter. In the odd ambulacrum the left poriferous zone is the shortest. In the continuation of the ambulacra from the rosette to the mouth it is always the exterior pore which is continued from each zone, and not pairs of pores, as is uniformly represented in all drawings of fossil Echinolampadæ. The floscelle round the mouth is most distinct, but in this specimen the bourrelets were not yet developed, formed as yet only by simple accumulations of small tubercles closely crowded together. In still younger specimens the resemblance of the opening of the actinal system to that of Clypeastroids is much greater, showing plainly that the distinction of a suborder, founded upon the presence of the bourrelets and phyllodes, as separating the Echinolampadæ from the Spatangoids cannot be maintained, and is simply an embryonic feature which may be more or less developed. The peculiar bare space of the actinal part of the test, so characteristic of Pygorhynchus, and upon which Desor lays so much stress, is well developed, though in older specimens of

Echinolampadæ it can be traced only as a faint, indistinct narrow band. The young of this Echinolampas resemble Caratomus to such an extent (see the description of the young stages) that the larger specimens were considered as living representatives of Caratomus. The series collected by Mr. Pourtales in his second expedition shows conclusively that Echinolampas passes at first through a stage strikingly similar to Echinoneus and subsequently most closely allied to Caratomus.

Note. — Desmoulins has called attention to the fact that the Senegal species should be named E. Laurillardi Desml., the name Richardii having been applied by him to a fossil species from the tertiaries of Bordeaux, from which it is different.

From 35 to 160 fathoms.

Rhyncholampas caribbæarum A. Ag., nov. gen.

Syn. Cassidulus caribbæarum Lam., An. s. Vert.
Cassidulus caribbæarum Lütk., Bid.
Nucleolites Richardii Duch., Antill. (non Desml.)

Lamarck's genus Cassidulus, as established in 1801, contains in it two distinct types: Cassidulus lapis cancri and the species from the West Indies; Cassidulus Marmimi has very justly been separated as a distinct genus, Rhynchopygus by Desor, but this still leaves Cassidulus of Lamarck composed of two types, for either of which the name Cassidulus might properly be retained, but as Cassidulus is preoccupied among Mollusca, I would propose to retain temporarily Cassidulus for the fossil species allied to C. lapis cancri, and leave to some palæontologist the task of properly limiting that genus, and separate from Cassidulus under the name of Rhyncholampas a genus including Cassidulus caribbæarum and its West Coast representative, which was originally named Pygorhynchus pacificus in the Museum Bull. No. 2. This view is the one Lütken adopted at first, but afterwards he has referred these two species to Rhynchopygus, a change which does not seem judicious, and which his own excellent analysis and comparison of Cassidulus and Rhynchopygus does not justify. Mr. Pourtales brought home fragments of this species, showing that it must equal in size its pacific representative. As it has been figured frequently, and described so well by Lütken, I will only call attention to a few points of difference between the East and West Coast species. The bare actinal band of the West India species is deeply pitted with longitudinal round and elliptical pores, the edges surmounted by minute tubercles, carrying extremely delicate spines, resembling in every respect the structure of the microscopic spines of the fascioles of the true Spatangoids. The spines in fascioles cannot be called pedicellariæ, although it is the universal practice: they are true spines, having all the structure of embryonic spines, — in fact, true pedunculated pedi-

cellariæ among Spatangoids are not found in fascioles at all; they are found round the mouth principally, and also on the surface of the test. The plates of the anal system, arranged in three rows, are broader and longer than in the Pacific species, where they are arranged in two rows only, the outer row being the largest. In the pacific species the pits of the smooth band are reduced to a few indistinct impressions, the whole band being thickly covered by minute silk-like spines. The floscelle is most distinct also, while, owing to the sculpture of the bare band round the mouth in the West India species, its outline cannot be traced.

Fragments in 106 fathoms.

Neolampas rostellatus A. Ag., nov. gen. et sp.

Outline from above resembling Echinolampas more elongated, three large genital openings; the left anterior one atrophied, placed closely together, madreporic body restricted to a narrow ridge separating them. Seen in profile, the test rises gradually from the anterior extremity towards the apical system, attaining its greatest height between it and the posterior extremity; this is sharply truncated anteriorly, as in some species of Catopygus. The lower extremity is concave, undulating; the anal system is large, elliptical, occupying the whole of the posterior truncated end, somewhat as in Botriopygus, the test being turned in like the finger of a glove, while the anus opens at the end of a long slender tube, extending well beyond the outline of the test, starting from the upper part of the anal membrane, which is covered by small plates, gradually diminishing in size and eventually firmly soldered together to form the base of the anal tube. Test thin, mouth placed near anterior extremity, having a well-developed floscelle and prominent bourrelets. The test is covered by minute tubercles of different sizes, not separated into primaries and miliaries, as in Echinolampas. The tubercles are not sunk, but stand out prominently from the test. The spines are straight, very fine, resembling those of the Scutellidæ. There is no ambulacral rosette so prominent in all Echinolampadæ. From an external examination alone it would be difficult to trace the course of the ambulacra, but from the interior we easily see one pore for each ambulacral plate extending from the floscelle to the apical system, and appearing as most minute pores when seen from outside. In fact, the structure of all the ambulacra is here identical with the structure of the ambulacra between the rosette and the mouth in other Echinolampadæ. The color of this Sea-urchin is a yellowish green, and I am convinced it is not the young of any other Echinolamp, in spite of its size ($\frac{7}{12}$ of an in.), owing to the great development of the bourrelets, which in other Echinolampadæ appear only after the specific characters are fully formed and the main features of the adult attained.

From 100 to 125 fathoms.

Pourtalesia miranda A. Ag., nov. gen. et sp.

A single specimen of this interesting genus was dredged at a depth of 349 fathoms. It is a living representative of Infulaster of the cretaceous period, holding the same relation to it which Rhynchopygus, with its projection covering the anus, holds to Echinolampas, if the posterior part of the test of the former were drawn out into a long spout. The outline of this genus, and of Infulaster, is very peculiar, and at first sight no one would take for a Sea-urchin the elongated, bottle-shaped body with its thin and transparent test. It is more like a Holothurian; the anus is nearly at one extremity, while the mouth is placed at the other. The short, vertical diameter, as compared to its length; the absence of any feature which would indicate the presence of a petaloid ambulacral rosette; the long, slender, curved spines, far apart, supported upon peculiar tubercles, mark this genus as one of the most interesting which have been brought to light by Mr. Pourtales. It forms a valuable link in our appreciation of the affinities of Spatangoids proper with Spatangoids in which the mouth is not labiate. Seen from above, the outline is bottle-shaped, the neck being the posterior extremity. At the base of the neck the test carries a deep pit, surmounted at its anterior extremity by a rostrum projecting from the test, and under this, at the bottom of the pit, is placed the anus. Seen in profile, the anterior extremity is almost vertically cut off, the test arching regularly from the apical system to the rostrum, where it is abruptly cut off, forming a regular curve to the posterior extremity, which extends beyond the anal system like a snout thickened at the end, surmounted at its extremity by an accumulation of minute deep violet-colored tubercles, which carry no spines. The lower surface is convex, regularly arched from the posterior to the anterior extremity. The posterior pair of ambulacra extend on both sides of an elongated plastron to the base of the snout-like prolongation, where they curve sharply upwards, and follow close to the abactinal part of the test, along a marked wedge-shaped ridge, extending from the apical system into the rostrum, protecting the anus, to the apical system, situated almost at the summit of the nearly vertical anterior extremity. The pair of anterior ambulacra take a similar course, but curve more regularly, and do not extend beyond the median line towards the posterior end. The odd ambulacrum is made up of two lines of pores far apart, situated in the deep anterior groove. The abactinal system consisting of four large genital openings, placed close together, with the madreporic body tolerably well defined in the centre, is situated at the origin of the anterior groove, this is flanked by prominent ridges extending from the apical system, gradually disappearing towards the mouth, placed at the other extremity of the anterior groove, which increases in depth on

the lower surface, resembling, in fact, the anal groove of Echinobrissus, and allied genera with inverted position. The actinal system is elliptical in the trend of the groove, very large, with sharply defined edges covered by very minute plates. There are no indications of a floscelle. The odd ambulacrum carries large, thick tentacles, with a slightly lobed disk, while the tentacles of the other ambulacra are peculiar. They are placed, one for each plate, far apart, branching at the extremity, strengthened by a rod separating in the three branches, each terminating by a well-marked disk. There is no petaloid portion in the ambulacra; they are all simple pores from the mouth to the apical system. The spines are long, curved at the base, as in Spatangoids, but the tubercles to which they are attached have not a sunken, scrobicular area. The mamelon is small, crenulated, perforate, surrounded by a large granulated, scrobicular area, and raised above the surface of the test, to which the milled ring is attached by a very flexible muscular membrane. There are smaller spines of a similar structure scattered irregularly over the test, but quite distant. The whole appearance of the test is bare, and it is only on the ridges along the anterior groove, round the mouth and anus, that the small spines are closely packed together. Radiating from the apex towards the mouth, and extending along the abactinal plastron, there are masses of pigment cells forming lines of dark violet spots, also a similar series of spots round the extremity of the anal prolongation of the test, particularly marked on the edge of the pit leading to the anal opening. From the above description it is evident that Infulaster and the Ananchytidæ must have had a structure allied to that of Pourtalesia, and are embryonic Spatangoids, still retaining some features of Clypeastroids, while the features characteristic of young Spatangoids are prominently developed.

Off the Tortugas in 349 fathoms.

Lissonotus fragilis A. Ag., nov. gen. et sp.

This genus has the general outline of Maretia, but is somewhat more elongate. It must, from the description of Grube, be closely allied to Platybrissus, but the presence of a subanal fasciole, as well as a slight anterior groove, readily distinguish the two genera, in addition to the presence of a rudimentary rosette in Platybrissus, wanting in this genus. The mouth is not labiate, but pentagonal, with a well-developed floscelle, while the remaining portion of the ambulacra, extending to the apical system, are simple pores, one for each ambulacral plate, so that the ambulacral areas, seen from above, are scarcely perceptible, marked only by the somewhat more closely packed minute tubercles covering the ambulacral plates. Seen in profile, the test is regularly arched anteriorly, from the lower side to the apex, running then almost horizontally, and abruptly bevelled at the pos-

terior extremity. The central plastron is small, triangular, surmounted by an elliptical subanal fasciole. The spines of the lower surface are large and few in number, confined entirely to the edge of the test, leaving broad, bare bands in the ambulacral areas and adjoining parts, while on the rest of the test the tubercles are minute, carrying small, fine spines, with the exception of three large, curved spines (Lovenia-like) near the circumference, placed in the anterior extremity of the test. The tubercles are also somewhat larger on the edge of the anterior groove, and more closely packed in the posterior interambulacral space, from the apex to the anal system, than in remaining parts of the test. The plates of the two posterior ambulacra are broad, while all the other ambulacra are made up of smaller plates. There are three large genital openings; the right anterior one is obliterated. The anal system is transversely elliptical, its membrane covered by minute granulation; an indistinct branch of the subanal fasciole extends along the lower side of the opening; the anus itself opens in a short, delicate tube, similar to that of Neolampas, but shorter. The whole test is mottled with dark spots; the ground color is grayish, with a purplish tinge.

From 320 to 368 fathoms.

Brissus columbaris Ag., Cat. Rais.

Littoral.

Meoma ventricosa Lütk., Bidrag.

Syn. Brissus ventricosus Ag., Cat. Rais.
" panis Grube, Neue Echin.
" spatiosus McCr., P. Pl. Foss. S. C., Pl. 3, fig. 1.

Lütken first referred this species to the genus Meoma of Gray, established for a presumed Australian species, M. grandis. Lütken also, in 1863, called my attention to the generic identity of Kleinia nigra A. Ag., with Meoma, which I had with doubt referred to Kleinia. This mistake I was led into by the fact that Gray himself did not refer Brissus ventricosus to Meoma, but still retained it in a section of Brissus. This shows how little reliance can be placed upon the subdivisions which Gray so frequently introduces in his genera (often copied without any attempt at a more accurate discrimination of the species from similar headings in the Catalogue Raisonné), when two species as closely allied as Meoma ventricosa and Meoma grandis are placed in two genera, or when in the subdivisions of Echinocardium, as another instance, Echinocardium ovatum is placed in the subdivision of the genus with "*deep, odd, ambulacral groove*," instead of being placed in the same subdivision as E. gibbosum. The genus Kleinia I am unable from Gray's figures and descriptions to distinguish from Brissopsis. Meoma grandis

GRAY, I am also inclined, from a careful comparison of the figures of Gray, to consider as identical with Meoma nigra (Kleinia nigra A. AG.), as the locality quoted by Gray is undoubtedly erroneous, Captain Belcher, as Lütken mentions in his "Bidrag," having visited Central America; and the fact that we have in the British Museum, brought back by Belcher, an Agassizia subrotunda GRAY, and a Meoma grandis GRAY, marked "Australia," neither of which can be distinguished from Agassizia ovulum and Meoma nigra, found upon the West Coast of Central America, seem to indicate without much doubt an error in the localities of the specimens of Gray's Catalogue.

Littoral, to 85 fathoms.

Plagionotus pectoralis AG., Agass. Cat. Rais.

Syn. Plagionotus pectoralis LÜTK., Bidrag.
" " " GRAY, Cat.
" Desorii GRAY "
" Holmesii, Ravenellianus McCR., Pl. Foss. S. C., Pl. 3, figs. 2, 3.

I am unable to appreciate the grounds upon which Gray distinguishes P. Desorii GR. from P. pectoralis AG. The figure he quotes as basis for his species is taken from the original Spatangus pectoralis LAM., which came from Bahia.

The identity of the pliocene and post-pliocene species here cited, as well as in the synonymes of the preceding and following species, is of course problematical; yet the differences indicated by McCrady do not indicate as great a range of variation as we find in living species. I have quoted the figures for the sake of calling attention to them. There are, in addition, other tertiary species described by Michelin and by Guppy, coming from the Gulf and the West India Islands; but as those represented in our collections are not accompanied by figures, I have not attempted to point out their affinities.

Littoral and fragments from 115 fathoms.

Brissopsis lyrifera AG., Agass. Cat. Rais.

The only difference to be traced, after a careful comparison, between Florida and European specimens is the existence of a distinct branch of the subanal fasciole extending round the anal system to the peripetalous fasciole. In European specimens there are traces of this branch, but it is not distinctly and sharply defined as in the Florida specimens. The subanal fasciole seems, from all I can gather after an examination of Spatangoids in various stages of growth, the only one subject to changes, and it is not

remarkable that we should have in Brissopsis similar variations, in the sub-anal fasciole, to these upon which Troschel has founded his genera Abatus Hamaxitus and Atrapus, — changes which, in Brissopsis at least, are due to different stages of growth. The character of continuity of the adjoining pairs of ambulacra, which Desor assigns to Toxobrissus as a distinguishing feature, does not constitute a sufficient basis for its separation from Brissopsis. This character is more and more apparent according to the size of the specimens; so much so, that we should place Brissopsis lyrifera, when young, in Brissopsis, but when full grown it would most decidedly pass for a Toxobrissus. If the subanal fasciole is really absent in Toxobrissus, it cannot, as Lütken considers it, be identical with Kleinia. It may be that other characters will yet be traced to separate it from Brissopsis; if not, then Kleinia and Toxobrissus will both become synonymous with Brissopsis.

From 55 to 156 fathoms.

Agassizia excentrica A. Ag., nov. sp.

Syn. Agassizia porifera McCr., Pl. Foss. S. C., Pl. 1, fig. 5.

I am somewhat inclined to consider this species as the Agassizia porifera; but not having any original specimens for comparison, and the drawings of Ravenel and McCrady showing rather striking differences, I will not take their identity for granted, and compare it only with the West Coast representative, from which it can at once be recognized by the position of the apical system, which is much more eccentric posteriorly; on this account the disparity between the odd anterior pair of ambulacra and the posterior pair is greater than in that species. The interambulacral plastron is elliptical, and with this exception the arrangement and proportion of the tubercles is that of A. ovulum Lütk. The peripetalous fasciole does not pass below the ambitus, and the posterior fasciole makes a sharp angle under the anal opening.

I am unable to distinguish Agassizia scrobiculata, of which authentic specimens are in the Museum collection, from A. ovulum. I must say, however, that Valenciennes's drawings in the Venus are not very faithful, and, from an identification based upon his figures alone, specific differences would readily become apparent.

From 36 to 115 fathoms.

Echinocardium ovatum Gray, Cat. Brit. M.

Syn. Amphidetus ovatus Ag., Agass. Cat. Rais.
E. orthonotus McCr., P. Foss. S. C., Pl. 2, fig. 1.

An examination of young specimens of Echinocardium cordatum shows that the generic distinction which I attempted to make between Amphide-

tus and Echinocardium, based upon the isolation of the anal from the subanal fasciole, and thus separating the group with a deep anterior groove from these with a slight anterior groove is untenable. The presence of three species of Echinocardium on both sides of the Atlantic is certainly remarkable, but I am unable to distinguish the fragments of specimens unmistakably identical with a fine specimen of Echinocardium ovatum collected at Charleston, S. C., in the Museum collection, from European specimens of this species.

Off Charleston bar; Florida in 128 fathoms.

Echinocardium lævigaster A. Ag., nov. sp.

The existence of several species of Echinocardium having the outline of Echinocardium cordatum, but the slight odd ambulacral groove of Echinocardium ovatum, is an additional proof of the identity of Echinocardium and Amphidetus, as they had been limited in the Museum Bulletin, No. 2. The present species, of which but a single specimen was collected, is closely allied to the Mediterranean E. gibbosum. Not having sufficient material to make a thorough comparison, which may prove their identity, I give the points of difference observed in the specimens compared. The abactinal ridge between the posterior ambulacra is quite prominent, extending as a well-marked rostrum over the anal opening; this is pear-shaped. The arrangement of the anal plates is similar to that of E. ovatum; the apical portion of the odd ambulacrum is narrow, the fasciole being elongated, elliptical; the sides of the test slope up very gradually from the ambitus; the apex is anterior to the centre; the whole upper surface of the test is covered by minute tubercles, with the exception of a few large ones along the edge of the ambulacral groove. The bare spaces of the ambulacra on the lower surface are very broad, the subanal plastron projects beak-like from the posterior extremity. which is nearly vertically truncated, but the beak is not as prominent as in E. gibbosum, where it becomes a striking feature.

From 79 to 121 fathoms.

Echinocardium Kurtzii Gir., Proc. Bost. Soc., 1852.

Syn. Echinocardium ampliflorum McCr., P. Foss. S. C., Pl. 2, fig. 2.
" " gothicum McCr. " " " Pl. 2, fig. 3.
" ? " cordatum Gray, Cat. B. M.

Girard has described as Echinocardium Kurtzii a species from Charleston (it occurs also in N. C.) closely allied to the European E. cordatum. Fragments of it were collected by Mr. Pourtales, and it may be interesting to compare our American species, of which the Museum possesses excellent series, with E. cordatum, with which future investigations may yet prove it identical, as the differences are confined almost entirely to a portion of the

test, subject to the greatest variation in Spatangoids. These consist in the greater prominence of the posterior abactinal interambulacral ridge; the anal opening is almost circular, and covered by a larger number of plates than in the European species, where they are larger and few in number. The extremity of the subanal plastron also projects beak-like, and is more prominent, though not as much as in E. lævigaster.

Littoral, to 85 fathoms.

Schizaster cubensis D'Orb., Agass. Cat. Rais.

Fragments of a true Schizaster, allied to S. gibberulus, were collected. These are referred with some doubt to the above species; especially if the determination of Dajardin is correct, who refers it to Periaster, and must have had access to the original specimen. The fragments have, however, the distinctive mark, given in the Catalogue Raisonné, of having the anterior ambulacrum much less sunken than in S. canaliferus, — a character which has nothing to do with Periaster.

Fragments from 80 fathoms.

Mœra atropos Mich., Rev. Mag. de Zool.

Syn. Schizaster atropos Ag., Agass. Cat. Rais.
Schizaster lachesis Gir., Proc. B. S., 1850.
Mœra lachesis Des., Synops.
Mœra atropos Lütk., Bidrag.

Fragments of this species were dredged from a depth of 80 fathoms. Girard has attempted to separate specimens from Texas, of slightly more elongated outline, as a distinct species. The color of M. atropos when alive is yellowish. The spines, where more thickly clustered, are brownish; they are short except where they cover the sunken ambulacra, which are entirely hidden by the spines meeting from both sides. On the lower surface, the interambulacral plastron is covered by long spines, which as they wear out at the extremity become spatula-shaped. On the side of the ambitus, and the upper lateral part of the posterior ambulacra, the spines attain a great length, especially towards the mouth, where they are most closely crowded together. Gray is particularly unfortunate in his subdivision of this genus; he has, like Michelin, divided Schizaster, but into three genera (following exactly the three types of the Cat. Rais.). "Nina" having for its type S. canaliferus, while S. gibberulus, which is most closely allied to it and cannot be separated generically, figures as Brisaster, and the most abnormal of the Schizasteridæ is retained as Schizaster. Michelin's subdivisions, made at the same time, have been adopted here.

The attempts made thus far to restore old generic names, in vogue before

Lamarck, and limit them to genera, as we understand them now, have been most confusing. Not that I would ignore writers who, like Breynius, Leske, Klein, Linck, were often far in advance of many modern publications, but when the so-called restoration amounts to sweeping out of existence genera which are well understood, and properly defined, and have been current in literature for more than half a century, and replacing them by generic names of doubtful limitation, I can consider such radical changes as anything but progress and justice. It seems to me that unless these changes are made with as much discretion and judgment as they have been made by Desor in his Synopsis, applying the old name to a subdivision, and retaining at the same time the current name for a portion of the genus thus subdivided, they are not calculated to advance our knowledge of Echinoderms. For instance, the attempt to substitute Echinanthus (which includes genera as widely different as Echinolampas, Conoclypus and Clypeaster) for Clypeaster, while D'Orbigny considered Echinolampas as identical with Echinanthus; the adoption of either view involves endless confusion, and Desor's solution is so natural that we must, as a general rule, take his definitions, in spite of the priority of this and many other restorations proposed by Gray, which are liable to similar objections.

Littoral, to 80 fathoms.

II. *On the Young Stages of Echini.*

From the large number of small-sized Echini collected by Mr. Pourtales it became necessary, in order to study them intelligently, to examine the young of as many species as possible, and obtain some criterion by which to determine this collection accurately. As the results to which this examination has led me form the basis of the preceding descriptions, it is not out of place to give the proofs, as far as they can be given by a short *résumé* and without figures, of the conclusions to which I have been led by the study of these young, leaving for a more elaborate paper a detailed description, as well as figures, of the changes here mentioned, which these young undergo. Some of the specimens collected by Mr. Pourtales are so small that they must have absorbed their Pluteus very recently before their capture. This collection, taken in connection with the Museum materials, gave the means of studying the changes due to growth of the following species: —

Cidaris annulata Gray.

Dorocidaris abyssicola A. Ag.

Diadema antillarum PHIL.
Garelia cincta A. AG.
Echinocidaris punctulata DESML.
" æquituberculata AG.
Echinometra VanBrunti A. AG.
Toxopneustes drobachiensis AG.
Echinus Flemingii BALL.
" melo LAM.
" gracilis A. AG.
Sphærechinus brevispinosus DES
Temnotrema sculptum A. AG.
Torcumatica concava GRAY.
Genocidaris maculata A. AG.
Trigonocidaris albida A. AG.
Lytechinus variegatus A. AG.
Tripneustes ventricosus AG.
Boletia granulata A. AG.
Echinocyamus angulosus LESKE.
Clypeaster rosaceus LAM.
Stolonoclypus prostratus A. AG.
Echinarachnius parma GRAY.
Encope emarginata AG.
Mellita testudinata KL.
" hexapora AG.
" longifissa MICH.
Fibularia volva AG.
Echinolampas caratomoides A. AG.
Echinocardium cordatum GRAY.
Brissopsis lyrifera AG.
Agassizia excentrica A. AG.

I doubt if without the aid of the information gained by the study of these young Echini a satisfactory report of this collection could have been made. The changes some species undergo are so great that nothing would have been more natural than to place the two extremes of the series not only in different species, but often in different genera, and even in different families. As a necessary consequence, the study of these young, showing what we may consider differences due only to growth, will lead to the elimination of numerous species and genera,

and give us hereafter a much more accurate basis in our limitation of genera, species, and the higher subdivisions. But it would be out of place here to do more than hint at this reform, especially as I trust soon to publish, in our Illustrated Catalogue, a Revision of the Echini, which has been undertaken, with the collections in the Museum and of the Smithsonian as a basis. I shall always consider myself fortunate to have had the opportunity — thanks to the liberality of the Superintendent of the Coast Survey — of examining this collection, forming the most valuable addition to our knowledge of recent Echinoids since the collections of the same order made by Stimpson in the Pacific.

In Toxopneustes drobachiensis Ag. soon after resorption of the Pluteus the young Sea-urchin has few large tubercles with mamelon, limited to the ambitus (Podocidaris and Podophora-like). The next stage has two principal rows of large tubercles occupying the whole test (Cidaris-like, no miliaries), increasing in number as they grow older, the spines gradually passing from a condition similar to those of Rhabdocidaris, Cidaris, Echinocidaris, and finally to Toxopneustes-like spines, as fast as the primary tubercles are formed, retaining their embryonic features most strongly while the spines are directly connected to the test, as in Podocidaris. In the earlier stages the actinal opening is large (Echinocidaris-like), without indentations (Cidaris-like), occupying nearly the whole of the actinal surface. As the test increases this opening becomes proportionally smaller, and slight cuts are formed (Psammechinus-like). The anal system is at first closed by a single subanal plate, appearing before the formation of the genital and ocular plates; it remains for a considerable period more prominent than the other plates, which are added to cover the enlarged anal system. The symmetrical axis of the subanal plate does not hold a fixed relation to the madreporic body, being opposite different genital plates in various stages of growth. This corresponds to the oblique position of the subanal plate in Salenidæ, when we take as starting-point the madreporic body. The abactinal system subsequently passes through a stage reminding us of Echinocidaris and Trigonocidaris, only there are five instead of four anal plates. The poriferous zone is at first narrow, the pores arranged in vertical rows; subsequently they are slightly arched vertically; they next separate into horizontal arcs of a smaller number of pores, increasing rapidly in number with age, and in small specimens we can trace their mode of formation, as the arcs near the ambitus are similar to those of

the adult, while those next the abactinal system are similar to the younger stages. The plates of the poriferous zone increase independently of the inter-ambulacral plates. The different stages of growth represent in the younger stages Cidaris, next Hemicidaris, then Pseudodiadema, Echinocidaris, Heliocidaris. The same general changes take place in Toxopneustes lividus, but the turban shape (Cidaris state) of the young test is more striking than in T. drobachiensis.

In Cidaris the difference between old and young stages is almost entirely limited to the proportionally larger size of the spines, and the more prominent serrations (recalling Salenocidaris). The abactinal system early assumes the character of the adult; in fact, with the exception of the smaller number of coronal plates, the above differences in the spines are the only important changes undergone in this genus. The same holds good for Diadema and Garelia, in both of which the spines are proportionally larger, and being so much less numerous gives to young Diadematidæ a peculiar facies (D. calamaria-like). We find also in young Diadema characters in the actinal membrane differing from the adult; the peculiar grouping, in five separate clusters, of the buccal ambulacral plates which appear first, is soon lost by the encroachment of the smaller interambulacral plates, and in older specimens the plates become deeply imbedded in the buccal membrane. The pores at first are placed in a vertical row in very young specimens; they then become arranged in arcs of three or four pairs; with increasing age the median rows of interambulacral tubercles assume the arrangement found in the adult. Owing to the rapid growth of the spines in the young, the extremity, and frequently the greater part of the spine almost to the base, is hollow; but as the young increase in age they become more solid at the base, and further up in proportion to their age.* Garelia is a good genus, as has been acknowledged by

* The genus Echinodiadema of Verrill is founded upon structural peculiarities of young Diadema mexicanum. Complete series of the young Diadema antillarum, from one tenth of an inch in diameter upwards, show that: the slight cuts, the shape of the abactinal system, the presence of small scales covering the anal system (few in number in very small specimens), the trigeminate arrangement of the pores, the hollowness (generally upper extremity only) of the spines, due to the mode of growth and subsequent solidification from the base upwards in Diadematidæ, the arrangement of the tubercles, the peculiar grouping of the plates of the buccal membrane, — features upon which the genus has been characterized, — are found in young Diadematidæ. I have carefully examined the type of Mr. Verrill's species, as well as young of Diadema mexicanum,

Bölsche, in letters subsequently to the "Nachtrag" to his Diadematidæ, in Wiegman's Archiv. The spines are solid, already longitudinally striated in the youngest specimens examined, differing totally in their structure from those of Echinothrix or Diadema. This shows plainly that in these embryonic Echini (Cidaridæ, Diadematidæ) the structure of the spines forms a good basis for the discrimination of groups notwithstanding their apparent great changes of form. These do not extend to the nature of the ornamentation, which remains very constant, and will prove of great value in fossil Echini.

Nowhere among the young regular Echini have I found such great changes in the shape and proportions of the test and spines as in Echinometra. We frequently find specimens of the same size, where in one case the outline is almost circular, the test flattened, covered with long slender spines, while in the other the test is lobed, swollen, high, surmounted by numerous short stout spines. These and all intermediate stages, complicated by the greater or smaller number of primary tubercles, the arrangement of the arcs of the poriferous zone undergoing changes exactly similar to those described in Toxopneustes, are found retained in specimens of very different size. This has given rise in a great measure to the confused synonymy attached to our most common species, and renders their identification, if based upon meagre material, almost hopeless.

In young Echinocidaridæ we have already in the youngest stages four anal plates. The abactinal system of very young specimens is remarkably prominent, occupying more than one half the abactinal part of the test. The whole test is deeply pitted (Trigonocidaris-like); the rudimentary tubercles, covering the greater part of the abactinal part of the test, are connected by ridges, which are gradually resorbed and reduced to the granulation found upon the coronal plates of the genus. The primary tubercles are at first limited to the ambitus, surmounted by short stout spines (Podophora-like), gradually becoming more slender and proportionally longer with increasing age (the opposite of what takes place in Toxopneustes, Cidaris, and most young Echini). The rudimentary spines are not seated upon tubercles; they are club-shaped (identical

of D. antillarum, and additional specimens of the so-called Echinodiadema coronatum, which has convinced me that Verrill's species is only a young Diadema mexicanum, the structural differences noticed being found in all young Diadematidæ I have had occasion to examine (D. antillarum, D. paucispinum, and D. mexicanum).

in structure to those of Podocidaris). The poriferous zone has in the earliest stages the structure found in the adult, only it does not widen at the actinostome. The ratio of the actinostome to test does not vary greatly in different stages of youth; the edge of the actinal system forming the groove of the gills is turned back but slightly in young, the lips taking the place of cuts becoming more prominent (Boletia-like) with increasing age. The separation of Echinocidaris and Arbacia to represent the groups with bare or crowded interambulacra is not natural, depending upon the greater or less resorption of the rudimentary tubercles formed in the earlier stages. It is very common to find young of Echinocidaris punctulata which would pass for young of Arbacia, and young Arbacia æquituberculata which would pass for young Echinocidaris. Owing to the independent growth of the plates of the poriferous zone, we have either three or four pairs of pores for each ambulacral plate; the same is the case with other Oligoporidæ, as limited by Desor, showing that the division he has made, convenient though it is as a key for the easier grouping of genera, is yet not strictly reliable, the mode of growth of many Polyporidæ showing in their young stages that they have but a small number of pores (Tripneustes, Mespilia) for each ambulacral plate which places them among the Oligoporidæ; but, owing to the independent growth of the plates of the poriferous zone in older stages, they seem to belong to the Polyporidæ.

In Echinus, Sphærechinus, Lytechinus, we find in the younger stages the same unbroken vertical arrangement of the pores, taking next a vertically arched form, still connected, and then assuming the arrangement of the adult. In these genera the anal system is at first covered by one plate, and undergoes changes similar to those of Toxopneustes, by the addition of four smaller plates, and so on, the original subanal plate retaining long a greater prominence. The miliaries are formed in these genera as well as Toxopneustes by radiating ridges arising from the base of the primary tubercles, forming a sort of star, then they swell at the distal extremity, forming a set of club-shaped spokes round the main tubercle; these are little by little separated from it, and become independent elliptical tubercles at first, and then miliaries or secondary tubercles. The ten large buccal plates of the actinal membrane are the first to appear. Small plates (in genera in which they are found in the adult) are next formed between them and the teeth (Echinus-like), while afterwards they cover the whole membrane, as in Lytechinus,

Psammechinus, Trigonocidaris, appearing between the ten plates and the test. This mode of growth is totally unlike the growth of the buccal plates of the Cidaridæ, where these plates perform the part of ambulacral and interambulacral plates, and appear near the test at first, forming in full-grown specimens rows made up of more than two plates, as in the Palæchinidæ, suggesting that the test of Palæchinidæ must have been made up of plates homologous to the buccal plates of Cidaris. The test of course would then have been capable of considerable compression and change of outline, as is the case in Astropyga and Asterosoma. This similarity is very striking in young Cidaridæ, where the number of coronal plates is small, and the young Sea-urchin seems to consist almost entirely of an abactinal and an actinal system, separated by a narrow band of coronal plates. Let this narrow band of coronal plates disappear entirely, and the buccal plates take a correspondingly great development, and we have a Palæchinus made up of small ambulacral and interambulacral plates consisting of several rows, and continuous from the teeth to the abactinal system, similar to that discovered by Meek and Worthen, the whole test surmounted by short spines, articulating upon a more or less distinct mamelon. The structural features of the buccal membrane of Cidaridæ entitle them to a higher rank than that of a family, in the suborder of Echinoids, intermediate between the Palæchinidæ and Echinidæ proper.

In the Temnopleuridæ (Toreumatica) the subanal plate remains very prominent in adult specimens; the anal system in the young is covered by one large elliptical plate; as the anal system enlarges, numerous minute plates surround the larger plate, which always retains its peculiar ornamentation, and is readily distinguished from the other by its size and shape. In Temnotrema, on the contrary, the anal system undergoes changes identical with those of Toxopneustes, Echinus, and the like. In Toreumatica, the pits at the angles of the plates appear at first like rectangular openings, which, as the specimens grow older, become little by little connected by grooves, growing deeper and more prominent with advancing age. The same is the case in Temnotrema; the pits, however, are never so marked in the adult, becoming simply comma-shaped. The miliaries in both these genera are formed as in other genera by ridges appearing at first connected with the base of the primary tubercles. In Trigonocidaris the young differ from the old in having larger pits, less numerous and lower ridges, and but few sec-

ondary tubercles, the principal rows of ambulacral and interambulacral tubercles being very prominent. The buccal membrane and abactinal system present no striking differences, the anal plates being only four in number in all the specimens collected. In Genocidaris, of which an extensive series was collected, we find in the smallest specimens a few large spines, resembling the spines of young Dorocidaris abyssicola, equalling in length the diameter of the test. As the specimens increase, the spines lose their spindle-shaped form and their serrate edge; they become more pointed and elongate, diminishing rapidly in proportion to the size of the test, and soon take the proportions they have in the adult. The actinal opening is very large at first, the test in young specimens being a narrow ring when seen from the actinal side. The primary tubercles are few in number, with remarkably prominent ridges radiating from them, leaving deep pits between the ridges. With increasing size these ridges become miliaries and secondary tubercles, the pits, however, remaining round the boss of the primary tubercles in both the areas; so that the test passes through stages in which it resembles at first young Psammechinus, then a Psammechinus with deep grooves radiating from the tubercles, and finally with deep pits round their base. The subanal plate retains always its preponderance, and the embryonic character of the anal system (retained in the generic name) is a marked feature of this interesting Sea-urchin. The actinal opening rapidly becomes smaller, and resembles that of Psammechinus. In fact, Genocidaris might be called a Psammechinus among Temnopleuridæ, while Toreumatica is the Lytechinus of the family.

The changes taking place in the arrangement of the pores in Tripneustes and Boletia are similar to those observed in Echinus; at first a simple vertical row, then arcs laterally curved, then three pairs of pores for each ambulacral plate, in oblique open curves, and finally almost horizontal curves, the pores appearing to be placed in independent vertical rows. Hipponöe of Gray cannot be retained, the name being preoccupied by Audouin, and as Hipponöe and Tripneustes are identical, the name Tripneustes can be retained to include the species of both these genera.

Among the Clypeastroids we find in the young during their growth great changes of form and structure taking place. In young Echinarachnius the outline is elliptical, the test is arched, high, the anus is placed in a slight depression of the test, and, seen in profile, we are re-

minded of the general aspect of Pygorhynchus. There are but two principal rows of large tubercles in each area, extending from apex to mouth, so that, seen from above, the young Echinarachnius has much the facies of an Echinometra. The mouth is large, pentagonal, its radius being half the radius of the test. The ambulacral rosette is reduced to two pairs of pores, — simple perforations of the test, one in each poriferous zone for each ambulacrum. This extraordinary shape and structure the young do not retain long; they soon become pyriform; the blunt extremity being the posterior, the test becomes greatly flattened and the anus approaches the edge. The rosette is now composed of three and two pairs of simple pores in each poriferous zone for each ambulacrum, the anterior ambulacrum having only two pairs in each zone. The tubercles are proportionally smaller, though there are still but two rows in each area, but further apart. In the next stage we find the rudimentary rosette composed of four and five pairs of pores close together and two or three distant pairs of pores, in the following ambulacral plates, one pair in each plate, which in subsequent stages increase in number and extend almost to the edge of the test. The test has become quite flattened, the lower side is concave, undulating, the ambulacral zones are now much narrower than the interambulacral ones. Each plate still has only one tubercle; the lines of separation between the two zones run straight from the edge of the test to the apex. It is only in somewhat older stages, when the rosette loses its radiating outline, and assumes a slightly petaloid shape, that we find the angle formed at the base of the petal in the ambulacral zone, from which point the ambulacral plates widen rapidly; each plate now carries from two to six smaller tubercles. The outline is quite pentagonal, the lower surface concave, but little undulating, the anus placed near the edge, and covered, as in all preceding stages, by one plate; the anal system in older specimens has five plates, the plate first formed remaining somewhat the largest. As the young Echinarachnius increases in size its outline becomes more circular, and in specimens measuring one fifth of an inch in diameter has the general appearance of the adult. The furrows joining the ambulacral pores appear soon after the first traces of a true rosette are seen; they become deeper and the pores separate in proportion with the petaloid structure of the abactinal part of the ambulacrum. The tubercles are proportionally much smaller and more numerous, and soon after the ambulacra have a well-developed rosette, bear nearly the ratio to the plates which they have in the adult.

Young specimens of Mellita hexapora, measuring $\frac{3}{32}$ of an inch in diameter, are almost circular, with a thickened raised edge, as in Laganum, and as yet have no lunules. The rosette is simply a series of radiating pores, three and two in each poriferous zone, for each ambulacrum, extending but a short distance from the apex. The ambulacral and interambulacral plates are of the same size, hexagonal, forming twenty equal zones, carrying but a single large tubercle in the centre of each plate; seen from below the surface is deeply concave, the mouth much larger in proportion to the test than in adult specimens, and we see forming from this side the posterior interambulacral lunule as a deep pit, at one extremity of which is placed the anus near the mouth, about one third the distance from the edge of the test. We find also rudimentary phyllodes made up of a few of the small pores, which eventually extend in the ambulacral furrows to the edge of the test, but are now restricted to a small number clustered round the mouth. The outline in a subsequent stage becomes slightly pentagonal, the plates elongate; the lunule pierces through to the abactinal side; the rosette is also radiating, made up of five to six pairs of pores for each poriferous zone. The ambulacral area is now slightly narrower than the interambulacral zones. When the posterior lunule has become a small round opening, encroaching upon the plates of the posterior interambulacral area, extending as a lobe beyond the outline of the test, the rosette is slightly petaloid. There are from two to five tubercles on each plate; they are quite elongate, having lost their hexagonal outline; the lower surface is flat, and on the lower side the ambulacra have broadened very rapidly, the interambulacra forming narrow bands carrying larger tubercles between the ambulacral zones. The edge of the test is still quite thickened, and it is only when the young Mellita has attained somewhat less than half an inch in diameter that the ambulacral lunules appear as pits, seen at first from the lower side only, and gradually forcing their way through the test. The posterior interambulacral lunule increases rapidly in size; the test and the groove in which the anus is placed become somewhat separated from it, being simply a depression in the continuation of the lunule. After the appearance of the lunules as slight pits, which develop unequally, not appearing simultaneously, the changes are limited to the increase in size of the lunules and of the poriferous ambulacral zone on the lower side; the outline and general facies, with the exception of the larger size of the tubercles, being that of the adult.

The general character of the changes undergone by Echinarachnius and Mellita hexapora, as far as they relate to the transformations of the ambulacral rosette, the growth of the tubercles, the changes in the proportions of the relative breadth of the ambulacral and interambulacral zones, are identical in Mellita testudinata and Encope emarginata. What is remarkable in Mellita testudinata is that the mode of formation of the ambulacral lunules is not identical with that of M. hexapora. The interambulacral lunule alone is developed from a depression formed on the lower surface pushing its way through the test, while the ambulacral lunules are the result of the closing in of notches appearing on the edge of the test, which remain open until the Mellita has attained a considerable size, — three quarters of an inch and sometimes more; long after the arrangement of the plates, the shape of the rosette, the size of the tubercles, and the extent of the poriferous zone on the lower surface have the character of the adult. In fact, the mode of development of Encope and of Mellita testudinata (also M. longifissa) are far more closely allied than that of the two species of Mellita of the types of hexapora and testudinata.

In Encope emarginata we have, as in Mellita, an early stage in which no posterior interambulacral lunule exists. The outline of these young Encopidæ is not Laganum-like, as in Mellita, but is elliptical, as in very young Echinarachnius; the ambulacral zones extending uniformly from edge to apex, are narrower than the interambulacral. The plates of both areas carry one to two large tubercles and a couple of very small ones. The ambulacral pores extend from the apex to the mouth. One pair of pores, not connected by grooves, is situated in the suture of each ambulacral plate. The outline seen from above is deeply scalloped — in fact, it is a Moulinsia, — and the figure given by Agassiz in the Monographie des Scutelles is only a young Encope emarginata. The posterior interambulacral lunule commences as a pit from the lower side, and by the time the young Encope has attained a diameter of three quarters of an inch, the lunule is seen from above, also as a small elliptical opening. The edge of the test is deeply scalloped, especially at the median ambulacral sutures, where notches soon appear, and the young Encope gradually takes a deeply lobed outline. These cuts may or may not close, and thus we have the basis of the great number of species established upon the depth of lobes, the presence or absence of certain lunules, which are nothing but features of the young either retained in the

adult or greatly exaggerated. The ambulacral rosette is formed as in Mellita and Echinarachnius by the independent growth of the upper part of the ambulacral area, which in Clypeastroids grows more rapidly than the rest of the test, from the moment the pores are joined by grooves, the plates crowding upon one another, and pushing them or part of them towards the edge of the test. In the Scutellæ the pairs of pores of the rosette are placed in the sutures of the ambulacral plates, while in the Clypeastroids, besides the pair of pores in the sutures an additional pair pierces the middle of each ambulacral plate.

The development of Stolonoclypus prostratus and flat Clypeastroids of the type of Clyp. placunarius is most instructive, tending to show that in connection with the development of the Scutellidæ above described, we must probably introduce a complete reform among the genera recognized as Lenita, Scutellina, Runa, Echinocyamus, and other minute Echinoids, which may eventually prove to be nothing but the young of other Clypeastroids, as Mellita, Scutella, Lagamum, Stolonoclypus, Clypeaster, Encope, and the like; but want of sufficient material prevents me from entering into this comparison more in detail. Though we know now, from what has been said above, that the Scutellidæ pass through phases which cannot be distinguished from Moulinsia, Fibularia, Runa, Scutellina, and the Clypeastroids proper pass, as I shall show below, through a stage of growth identical with Echinocyamus. For similar reasons I am inclined to consider Fibularia as the early stage of some Clypeastroid. The absence of partitions in some species, I think, can easily be accounted for, as they are developed only later. We have a species of Fibularia from the Sandwich Islands, in which there are no partitions when very small, while in the adult these partitions are most rudimentary. Greater material than I possess is necessary to elucidate the affinity of the genus, which certainly has all the features of immature Clypeastroids.

Among the Echini, collected in great numbers by Mr. Pourtales, was a small species showing, on careful examination, the facies of Echinocyamus, and which, after a minute comparison with Echinocyamus pusillus, I could only distinguish from it, by its more circular outline, larger tubercles, less crowded and thinner interior partitions; observing, however, in the horizontal sutures of the ambulacral plates, rows of minute pores, extending from the imperfect rosette to the mouth, I at once saw that it must be a young Clypeaster, and on comparing them with

young Stolonoclypus prostratus, measuring half an inch in length, recognized a similar arrangement in the ambulacral zone, below the rosette. It was now plain that our Florida Echinocyamus was only a young Stolonoclypus prostratus, which in the earlier stages is identical in every structural feature with Echinocyamus; for European specimens of Echinocyamus show the presence of similar horizontal rows of pores, as in our young Stolonoclypus from Florida. I am well aware that no Clypeaster has been found in European seas, yet we have evidently such an incomplete knowledge of the marine Fauna, existing at great depths, to judge from the collections made by Mr. Pourtales, that negative evidence can no longer be admitted in opposition to such positive proof as we find in Florida. The larvæ referred by Müller to Echinocyamus were not raised by artificial fecundation; they do not resemble Spatangoid or Clypeastroid larvæ, but seem closely allied to true Echinidæ larvæ. Can they not be larvæ of Cidaris hystrix and of Cidaris papillata — which would account for the presence of such forms in the North Sea and Mediterranean — rather than be referred to Echinocyamus? Very small specimens varied in the number of the tubercles on each plate, the number of pores of the imperfect rosette, the changes being similar in kind to those observed in the Scutellidæ. From the Echinocyamus stage they become more pentagonal; the concavity of the lower side increases, the partitions increase by the addition of needle-shaped processes, and they soon attain the shape and structure given by Lütken in his figures of young Stolonoclypus prostratus. The tubercles increase more rapidly near the edge of the test, and a remarkable feature of these stages is the presence of minute glassy tubercles similar to those of Echinoneus, developing side by side with young tubercles, the function of which is as obscure as it is in Echinoneus, and which are not found in older specimens.

The development of Echinolampas has thrown unexpected light upon the affinities of the toothless Galerites and of the Cassidulidæ. It shows conclusively that Echinoneus is only a permanent embryonic stage of Echinolampas, thus becoming allied to the Cassidulidæ, and that it has nothing in common with the Galerites as I would limit them, confining them entirely to the group provided with teeth. This reduces the type to a most natural division, and from what we now know of the simple nature of the ambulacra of all Echini in their early stages, I would not give to this feature the significance which it has received,

but would be inclined to unite the toothed Galerites with Echinidæ proper in the same suborder, as a prophetic family, approaching the Clypeastroids by the separation of the anus from the apical system, and retaining the teeth and general symmetrical structure of the regular Echini. Though I am aware that the great development of Galerites in former geological periods, and the relation of the anus and test, may, on further acquaintance with living representatives, entitle them to rank as a suborder intermediate between the Echini proper and Clypeastroids. Young Echinolampadæ, measuring a trifle over one eighth of an inch, are elliptical, resembling Echinoneus, with a large transverse elliptical mouth, the anus placed in the truncated posterior extremity above the ambitus. The outline in profile is almost globular, each plate of the narrow ambulacral zone carries a single principal tubercle, surrounded by a circle of miliaries. The pores are arranged in a vertical row of a single line of pores, three or four for each plate, extending from mouth to apex. The interambulacral plates are elongated horizontally, and carry from one to three principal tubercles, with numerous small miliaries arranged in circles round the primaries, or irregularly scattered. In specimens twice the size of the above, the test is less elliptical, more flattened, and the first trace of a rudimentary rosette appears as a short row of double pores extending from the apex, consisting of from eight to nine pairs, only in one of the poriferous zones of each of the pairs of ambulacra — in the anterior zone of the posterior pair and the posterior zone of the anterior pair of ambulacra — the odd ambulacrum remains simple. In specimens measuring above half an inch this rudimentary one-sided rosette has increased in length, and traces of the second row of double pores are seen in the simple zones near the apex. In specimens measuring an inch these rows have grown to be half as long as the arc of the rosette first formed; the same structure has also extended to the abactinal part of the odd ambulacrum. The elliptical outline is entirely lost in these specimens, the shape having gradually become more circular, pentagonal, and ovoid. At the same time the miliary tubercles increase rapidly in number, forming clusters of small tubercles, embossing the plates of both areas. The anal system is covered by three large triangular plates, the anus opening near the edge of the system, in a narrow slit covered by very minute plates. The mouth, as the young increase in size, becomes more and more sunken. The buccal membrane is covered with minute plates, the

mouth opening in the centre. There are as yet no signs of phyllodes or of bourrelets, which appear only later, the bourrelets being at first accumulations of small tubercles between the phyllodes. When measuring about half an inch in length, the young Echinolampas resembles Caratomus to such an extent that this stage was considered for a time a living representative of Caratomus. The larger series collected by Mr. Pourtales, in his second expedition, showed conclusively the relationship to Echinolampas, and proves the correctness of the step taken by Desor in removing Caratomus and allied genera from the Galeritidæ, and placing them among the Cassidulidæ, on account of the semipetaloid nature of the apical portion of the ambulacra. Pedicellariæ with a short stem are irregularly scattered over the test; the spines resemble those of Clypeastroids, being short, slender, straight, the secondary spines silk-like. The tentacles, as far as could be ascertained from alcoholic specimens, are provided with a powerful sucking disk, as long as they retain the aspect of Caratomus.

Among Spatangoids proper, the examination of young specimens shows that they undergo great changes in outline during their growth, that the posterior part of the test is especially subject to variation, that the position of the anus is exceedingly variable in one and the same species, that the mouth is not labiate in the young as in the adult, that the peripetalous fascioles and lateral fascioles do not change in their limits, but that the subanal and anal fascioles are liable to great modifications during their growth, and cannot be used as distinguishing features of generic value, while the permanence of the peripetalous and lateral fascioles is of great systematic value. The ambulacral petaloids also are greatly modified with age, generally becoming confluent, while in the young they are remarkably distinct and the pores not conjugated. The semitæ are not covered by regular pedicellariæ, as is universally stated to be the case. We find on the fascioles minute tubercles carrying embryonic spines. Troschel was the first to call attention to this, and Müller has subsequently, in his Embryology of the Echinoderms, given accurate figures of the spines of the fascioles of S. canaliferus, in his sixth Memoir, Plate VII. figs. 7 – 9. Yet these observations, dating back to 1852, seem to have escaped the attention of recent writers, who persist in stating that the fascioles carry true pedicellariæ. These are found irregularly scattered over the test, generally more abundantly round the mouth. From the examination of the pedicellariæ made in

some of the genera of this collection (Podocidaris), there can now be no doubt that pedicellariæ are nothing but modified spines; the existence of pedicellariæ surmounting a tubercle and moved by the same mechanism as spines, as well as the mode of formation of the pedicellariæ, as observed in Asteracanthion and Spatangoids, by Müller and myself, proves conclusively that they are only more sensitive spines, performing the functions of scavengers or of providers, according to their position.

The Cassiduloid-shaped mouth of young Spatangoids, as well as the existence of several Spatangoids, both fossil and recent, in which the mouth has a similar structure, is as convincing a proof as necessary of the correctness of uniting Cassiduloids and Spatangoids in the same suborder, though the name given by Albin Gras, of "Irregular," is hardly what could be desired.

Young Brissopsis lyrifera, less than a quarter of an inch in length, are cylindrical, the mouth having a flat, crescent-shaped edge, the test truncated vertically at the posterior edge, surrounded by a prominent elliptical sub-anal fasciole; the peripetalous fasciole is elliptical, undulating; the anus is placed near the posterior extremity of the fasciole. The odd ambulacrum carries four or five large tentacles with lobed disk; the pores of the odd ambulacrum are single, not in pairs; the other ambulacra are short, straight, well defined, consisting of three and four pairs of pores not yet conjugated. In older specimens the posterior edge of the mouth becomes labiate, the anus approaches the subanal fasciole, which sends out a rudimentary anal branch, eventually uniting with the peripetalous fasciole, the outline of which becomes more pentagonal, undulating, and elongated with the increasing size of the petaloid ambulacra. The posterior edge becomes more bevelled with age, the subanal plastron more prominent, the lateral pairs of ambulacra gradually tend to unite, passing from a strictly Brissopsis outline to one considered hitherto characteristic of Toxobrissus. The spines in all young Spatangoids are strikingly larger in proportion to their size than in the adult.

In Echinocardium cordatum the changes of the mouth, of the outlines of the internal ambulacral fasciole, and the gradual confluence of the lateral ambulacra are similar to those of Brissopsis; the posterior extremity undergoes the greatest change in outline; the subanal plastron is very prominent; in fact, the outline of young E. cordatum recalls E. gibbosum. The subanal fasciole and anal branch are at first united,

but as the specimens increase in size, the anal branch separates from it. The odd ambulacral pores are at first two single rows of pores, which by closer crowding eventually alternate, but are not arranged in pairs.

The young Agassizia, a quarter of an inch in length, is a flat elliptical Spatangoid resembling Gualteria. The petaloid and lateral fascioles have the same general limits as in the adult, but the arrangement of the pores in all the ambulacra is identical; there is but a single pore for each ambulacral plate, as it exists in the anterior pair and odd ambulacra of the adult; the ambulacral grooves are not yet formed, the anterior groove alone being slightly indicated; the mouth is not labiate.

The great number of Spatangoid genera established upon differences in the subanal fasciole, the existence or absence of the anal branch, the depth of the ambulacral grooves, the confluence or distinctness of the lateral ambulacra, all based upon characters subject to great variation during growth, show the necessity of a careful revision of the whole group of Spatangoids with the data here furnished; and such closely allied genera as Maretia, Spatangus, Hemipatagus, and Macropneustes; Eupatagus, Plagionotus, and Metalia; Meoma and Linthia; Agassizia, Prenaster, and Periaster; Gualteria and Brissopsis; Tripylus, Desoria, Abatus, and many others, must be re-examined and critically revised before we can attempt an arrangement of Spatangoids into natural families.

The subordinal divisions usually adopted since their introduction by Albin Gras do not seem satisfactory, if tested by our present information. In the first place, the whole classification is based upon the separation of the anus from the abactinal system. From what the Embryology of Echini has taught us, the position of the anus has not the physiological importance attributed to it by authors who have so generally received this classification. The unstable position it occupies in the same animal at different stages of growth — at one stage opening next to the mouth, then on the margin, and finally opening in the central part of the apical system in the adult — should make us hesitate to adopt a single anatomical feature as our sole guide. In the first place the order of Perischœchinidæ, a most natural one, is founded upon characters derived from the structure of the interambulacral and ambulacral systems. The other two suborders, regular and irregular, usually recognized, can scarcely be called natural. The suborder of regular Echini is more satisfactory than the other, though, from what I

have said of the Galerites with teeth, I should be inclined to add them to the suborder as one of its three subdivisions, which, as here limited, are the Cidaridæ, the Echinidæ proper, and the Galerites. The suborder of "irregular" Echini, after the withdrawal of the Galerites, still contains the Clypeastroids. From the structure of the ambulacral system, they have some affinity with the Spatangoids; yet the presence of partitions and teeth, combined with petaloid ambulacra, seem to constitute good subordinal characters for the Clypeastroids as contrasted with the Spatangoids proper, which include all edentate forms, taking in also the edentate genera formerly placed among Galerites as well as the Cassidulidæ, sometimes regarded as independent suborders.

III. *Bathymetrical and Geographical Distribution.*

The accompanying table (pp. 298 and 299) shows at a glance the principal features of distribution of the different zones of depth. We can distinguish a strictly littoral fauna, extending from tide-mark to generally less than 10 fathoms, though a few of the species characteristic of this zone extend to a depth of 31 and 40 fathoms. This fauna consists of

Diadema antillarum.
Echinometra Michelini.
" viridis.
Lytechinus variegatus.
Tripneustes ventricosus.
Clypeaster rosaceus.
Stolonoclypus Ravenellii.
Mellita testudinata.
Encope Michelini.
" emarginata.
Echinoneus semilunaris.
Brissus columbaris.

A second set of species, less numerous, extends from the shore to a much greater depth, — from 80 to about 120 fathoms. They are

Cidaris annulata.
Echinocidaris punctulata.
Meoma ventricosa.
Plagionotus pectoralis.
Mœra atropos.

At a depth of 30 to 40 fathoms commences a third set of species, the majority ranging to about 160 fathoms, though two species range to 270 fathoms, marked *, and a few species commence at a greater depth, 80 to 90 fathoms. These species are

* Dorocidaris abyssicola.
Echinus gracilis.
Genocidaris maculata.
* Trigonocidaris albida.
Rhyncholampas caribbæarum.
Echinolampas caratomoides.
Neolampas rostellatus.
Brissopsis lyrifera.
Agassizia excentrica.
Echinocardium ovatum.
" lævigaster.
" Kurtzii.
Schizaster cubensis.

At a depth of about 140 fathoms, extending to over 310 fathoms, are found most interesting species:

Cænopedina cubensis.
Podocidaris sculpta.
Echinus Flemingii.

While near the lowest depth reached by the above species we strike upon a peculiar fauna recalling types of the cretaceous period, extending from 315 fathoms to the greatest depth attained in the straits between Florida and Cuba. These are

Salenocidaris varispina.
Pourtalesia miranda.
Lissonotus fragilis.

Two species — Stolonoclypus prostratus and Mellita hexapora — have the greatest bathymetrical range, extending from the shore, the one to 270 fathoms and the other to 325 fathoms. I would state, however, that it is only the young which have this great range; the adult specimens are limited to a quite shallow zone, — about 40 fathoms. In the young of our common northern Cuvieria the reverse takes place, the young being quite common at low-water-mark, while young Echinarachnius and T. drobachiensis are found at a much greater depth than the adult. I

Note. — Figures denote depth in fathoms; range of a species is indicated by the horizontal lines; thus, 138——270 in Cœnopedina shows its range from 138 to 270 fathoms. Figures at head of column to be taken, where no others are given.

	Lit.	10	20	40	60	80	100	120	140	160	180	200	220	240	260	280	300	320	340	360	380
Cidaris annulata Gray	——	——				——		116													
Dorocidaris abyssicola A. Ag.					——	——	——	——	——	——	——	——	——	——	——	270					
Salenocidaris varispina A. Ag.																		315			
Diadema antillarum Phil.	——	——	17																		
Cœnopedina cubensis A. Ag.									138	——	——	——	——	——	——	270					
Echinocidaris punctulata Desml.	——	——	——	——	——	——	——	——	125												
Podocidaris sculpta A. Ag.									138	——	——	——	——	——	——	——	——	315			
Echinometra Michelini Des.	——7																				
" viridis A. Ag.	——7																				
Echinus gracilis A. Ag.							93	——	——	——	——	——									
" Flemingii Ball												195									
Genocidaris maculata A. Ag.			30	——	——	——	——	——	——	——											
Trigonocidaris albida A. Ag.					——	——	——	——	——	——	——	——	——	——	——	270					
Lytechinus variegatus A. Ag.	——	——	——	34																	
Tripneustes ventricosus Ag.	——																				
Clypeaster rosaceus Lam.	——5																				
Stolonoclypus prostratus Ag.	——	——	——	——	——	——	——	——	——	——	——	——	——	——	——	——	——	——	325		
" Ravenellii A. Ag.	——	——	——	34																	

	Lit.	10	20	40	60	80	100	120	140	160	180	200	220	240	260	280	300	320	340	360	380
Mellita testudinata Kl.	—7																				
" hexapora Ag.																270					
Encope Michelini Ag.		11																			
" emarginata Ag.	—7																				
Echinoneus semilunaris Lam.																					
Echinolampas caratomoides A. Ag.				35	—	—	—	—	—	160											
Rhyncholamaps caribbæarum A. A.						106															
Neolampas rostellatus A. Ag.							—	—	125												
Pourtalesia miranda A. Ag.																				349	
Lissonotus fragilis A. Ag.																		—	—	—	368
Brissus columbaris Ag.	—																				
Meoma ventricosa Lütk.	—	—	—	—	—	—	85	115													
Plagionotus pectoralis Ag.	—	—	—	—	—	—	—	—	—	156											
Brissopsis lyrifera Ag.				55	—	—	—	115													
Agassizia excentrica A. Ag.			36	—	—	—	—	—	128												
Echinocardium ovatum Gray.						79	—	—	121												
" lævigaster A. Ag.						79	—														
" Kurtzii Gir.	—	—	—	—	—	—	85														
Schizaster cubensis D'Orb.							—														
Mœra atropos Mich.	—	—	—	—	—																

have given the greatest depth of living young, as the dead tests may have been dropped by fishes or carried by currents. The character of the Echinian fauna, on the three belts developed by the soundings of Mr. Pourtales, are tolerably well defined; the first zone being littoral, and extending to 90 fathoms, is characterized by species, the majority of which do not range beyond 40 fathoms, with a few species ranging somewhat beyond, to about 120 fathoms.

The second zone (from 90 to 250 fathoms) is characterized by species extending into the first somewhat and attaining a range of about 270 fathoms, with an admixture of a few species extending from 140 to 310 fathoms.

The third zone contains the typical deep-sea species of Florida, extending from 315 to 500 fathoms.

Although we have not a sufficient number of soundings to establish homogeneous zones of geographical and bathymetrical range, an analysis of the above grouping of species shows us something analogous to the distribution of animal and vegetable life in latitude and height; the oceanic distribution being of course an identity for northern latitudes and southern depth, or a representation by species closely allied.

For instance, we find littoral, as far north as North Carolina, Mœra atropos, Echinocardium Kurtzii, and as far as the southern part of Cape Cod Echinocidaris punctulata, species which in Florida have a range in depth to 125 fathoms. Of their range further north we know nothing.

The following North-European species — Cidaris papillata, Schizaster fragilis, Echinus Flemingii, Echinocardium ovatum, E. cordatum, Echinocyamus? pusillus, Brissopsis lyrifera — are represented by their allies or by the identical species: viz. Dorocidaris abyssicola, Schizaster cubensis, Echinus gracilis, E. Flemingii, Echinocardium ovatum, E. Kurtzii, Stolonoclypus prostratus, Brissopsis lyrifera, which have a range somewhat more extensive than the previous species. These same species, with the addition of Brissus columbaris, Echinocardium lævigaster, Diadema antillarum, and Echinocidaris punctulata, are again the representatives of a Mediterranean fauna strikingly similar, consisting of Cidaris hystrix, Schizaster canaliferus, Echinus melo, Echinocardium cordatum, Echinocyamus? pusillus, Brissopsis pulvinata, Brissus Scillæ, Echinocardium gibbosum, Diadema europæum, Echinocidaris

æquituberculata. The specific representation on both sides of the Isthmus of Panama is becoming every day, as far as Echinoderms are concerned, more strikingly identical. Since the list given by Mr. Verrill, several species have come to light, and the following comparative list of species on both sides of the Isthmus, extending from Peru to the Gulf of California on the Pacific, and including on the Eastern side the Gulf of Mexico, Florida, the northern coast of South America, the West Indies and Bahamas, may not be out of place. (I have examined all the species here named.) This list would undoubtedly be greatly increased by additional dredging.

Eastern Fauna. (*Caribbean.*)	Western Fauna. (*Panamic.*)
Cidaris annulata Gray	Cidaris Thouarsii Val.
Dorocidaris abyssicola A. Ag.	
Salenocidaris varispina A. Ag.	
Diadema antillarum Phil.	Diadema mexicanum A. Ag.
	Astropyga venusta Ver.
Cænopedina cubensis A. Ag.	
Echinocidaris punctulata Desml.	Echinocidaris stellata Ag.
Podocidaris sculpta A. Ag.	
Echinometra Michelini Des.	Echinometra Van Brunti A. Ag.
" viridis A. Ag.	" rupicola A. Ag.
Echinus gracilis A. Ag.	
" Flemingii Ball.	
Genocidaris maculata A. Ag.	
Trigonocidaris albida A. Ag.	
	Toxocidaris mexicana A. Ag.
Lytechinus variegatus A. Ag.	Lytechinus semituberculatus A. Ag.
	Psammechinus pictus Ver. is the young.
	Boletia rosea A. Ag.
Tripneustes ventricosus Ag.	Tripnenstes depressus A. Ag.
Clypeaster rosaceus Lam.	
Stolonoclypus prostratus Ag.	
" Ravenellii A. Ag.	Stolonoclypus rotundus A. Ag.
Mellita testudinata Kl.	Mellita longifissa Mich.
" hexapora Ag.	" pacifica Ver.
Encope Michelini Ag.	Encope grandis Ag.
" emarginata Ag.	" micropora Ag.
	Echinoglycus Stokesi Gray.
Echinoneus semilunaris Lam.	
Echinolampas caratomoides A. Ag.	

Eastern Fauna.	Western Fauna.
Rhyncholampas caribbæarum A. Ag.	Rhyncholampas pacificus A. Ag.
Neolampas rostellatus A. Ag.	
Pourtalesia miranda A. Ag.	
Lissonotus fragilis A. Ag.	
	Lovenia sp.
Brissus columbaris Ag.	Brissus obesus Ver.
Meoma ventricosa Lütk.	Meoma grandis Gray.
Plagionotus pectoralis Ag.	Plagionotus nobilis A. Ag.
Agassizia excentrica A. Ag.	Agassizia scrobiculata Val.
Brissopsis lyrifera Ag.	
Echinocardium ovatum Gray.	
" lævigaster A. Ag.	
" Kurtzii Gir.	
Schizaster cubensis D'Orb.	
Mœra atropos Mich.	Mœra clotho Mich.*

With the exception of three Panama species, all the West Coast species have representatives on the Eastern Coast. The Eastern species which have not as yet been found represented on the West Coast are the deep-water species of Mr. Pourtales's collection, and, what is very peculiar, a few species, like Clypeaster rosaceus, Echinoneus semilunaris, Echinocardium Kurtzii, and Echinolampas, belonging to genera which have a most extensive range, — in fact, an almost cosmopolitan one, — are found everywhere in the great Indo-Pacific belt, and its continuation on the West Coast of Africa, extending also to the temperate zones, on both sides of this equatorial belt.

The relation of the Caribbean Fauna with the existing geographical distribution of Echini is shown by the accompanying faunal table (p. 303), including only strictly representative species.

We have in Genocidaris maculata and Trigonocidaris albida representatives of the Temnopleuridæ, thus far limited almost entirely to the Indian and China seas. The littoral species having the most limited bathymetrical range are those which have the widest geographical distribution. They are Tripneustes ventricosus, Diadema antillarum, Cidaris annulata, Echinometra Michelini, Lytechinus variegatus, Mellita testudinata, Encope emarginata. Some of these species extend from the southern part of Brazil to the Bermudas. They all belong to

* Astriclypeus Manni Verrill is found in Japan. Mr. Verrill did not know the exact origin of his specimen.

Caribbean.	Panamic.	Europ. Boreal.	Mediterranean.	Senegal.	Indo-Pacific.	Chinese.	Japanese.	Patagonian.
Cidaris annulata GRAY	*			*i.*	*			
Dorocidaris abyssicola A. AG.		*	*		*			*
Salenocidaris varispina A. AG.								
Diadema antillarum PHIL.	*		*	*	*	*	*	
Cænopedina cubensis A. AG.								
Echinocidaris punctulata DESML	*		*	*				
Podocidaris sculpta A. AG.								
Echinometra Michelini DES.	*			*	*		*	
" viridis A. AG.	*				*			
Echinus gracilis A. AG.		*	*					
" Flemingii BALL		*i.*	*i.*					
Genocidaris maculata A. AG.							*	
Trigonocidaris albida A. AG.						*		
Lytechinus variegatus A. AG.	*				*			
Tripneustes ventricosus AG.	*				*		*	
Clypeaster rosaceus LAM.				*				
Stolonoclypus prostratus AG.		*	*		*		*	
" Ravenellii A. AG.	*							
Mellita testudinata KL.	*							
" hexapora AG.	*							
Encope Michelini AG.	*							
" emarginata AG.	*							
Echinoneus semilunaris LAM.					*		*	
Echinolampas caratomoides A. AG.				*	*			
Rhyncholampas caribbæarum A. AG.	*							
Neolampas rostellatus A. AG.								
Pourtalesia miranda A. AG.								
Lissonotus fragilis A. AG.								
Brissus columbaris AG.	*		*		*			
Meoma ventricosa LÜTK	*							
Plagionotus pectoralis AG.	*							
Brissopsis lyrifera AG.		*i.*	*		*			*
Agassizia excentrica A. AG.	*							
Echinocardium ovatum GRAY		*i.*	*i.*					
" lævigaster A. AG.			*					
" Kurtzii GIR.		*	*				*	
Schizaster cubensis D'ORB.		*	*		*			
Mœra atropos MICH.	*							

NOTE. — *i* denotes identity of species; * denotes representative species.

genera having representatives in the great tropical belt surrounding the globe, formed by the Indo-Pacific, Mediterranean, Senegalian, West Indian, Panamic, and Polynesian faunæ, — such as Cidaris, Diadema, Echinometra, Tripneustes, Clypeaster, Stolonoclypus, Echinolampas, Echinoneus, Brissus, the species of which have a great geographical range, and are represented by the following species: —

Cidaris metularia, Tripneustes sardicus, Echinometra lucunter, Diadema Savignyi, Clypeaster Rangianus, Stolonoclypus placunarius, Echinolampas oviformis, Echinoneus cyclostomus, Brissus carinatus, all of which have an immense geographical distribution.

The effect which currents play in shaping the geographical distribution of marine animals is very great; we have an example in the Gulf Stream and the northern branch of the Amazonian current flowing into the Gulf of Mexico, which account fully for the great range of the more common littoral species. The Japanese current makes itself felt as far as San Diego, two species of Echini extending in the Northern Pacific from the northern part of Japan along Kamtchatka, the Aleutian Islands, Sitka, Vancouver's Island, the one as far as Cape Mendocino (T. drobachiensis), the other (Dendraster excentricus) to San Diego. The Indo-Pacific equatorial current has undoubtedly been the main agent of the extensive geographical range of such species as Cidaris metularia, Echinoneus cyclostomus, Heterocentrotus mammillatus, Diadema Savignyi, Tripneustes sardicus, Echinolampas oviformis, Brissus carinatus, Stolonoclypus placunarius.

The effect of currents in thus extending the distribution of marine animals would act very differently upon the several classes of the animal kingdom, and its efficiency depends to a great extent upon the nature of their earlier stages, and upon their habits during that period. The time during which the Pluteus of Echini remains helpless at the mercy of the currents is considerable: from early spring till late in the summer is the usual time required for the full growth of the Pluteus in many species of Sea-urchins, and the distance which the young could thus be transported, even by a sluggish current, during a single season, must be considerable, even under the most unfavorable circumstances.

Various writers have attempted to retrace, in former geological periods, the probable course of the currents and their effect upon the geographical distribution of marine animals; they all agree in representing up to the cretaceous period an unbroken equatorial current,

passing through Central Asia, Arabia, the northern part of Africa, and connecting with the Pacific by a narrow strait through the Isthmus of Panama. The existence of this connection in the cretaceous period is placed beyond doubt by the presence of an Ananchytes, which I am unable to distinguish from Ananchytes radiata, collected on the Isthmus of Panama, and now in the Museum of Yale College, kindly loaned me for examination by Professor Verrill. From the small number of identical species, either of Mollusca, Crustacea, or Fishes, recorded on both sides of the Isthmus, this connection must have been very imperfect at a comparatively recent geological period, — since the existence of the present Faunæ.

The question naturally arises, Have we not in the different Faunæ of both sides of the Isthmus a standard by which to measure the changes which these species have undergone since the raising of the Isthmus of Panama and the isolation of the two Faunæ? If the upheaval of the isthmus has been gradual, it must, of course, have cut off the deep-water species on both sides of the isthmus, and gradually have isolated the more shallow, till the littoral species also became separated. As a natural consequence, the deeper we go, the farther back in time we must expect to find the representation, — a result which is strikingly confirmed by the nature of the deep-water Fauna of the West Indies. Unfortunately we have not, as in the case of the littoral Faunæ, a standard of comparison. At the same time, with the gradual closing of the Isthmus of Panama, the greater part of Central Asia, of the Arabian Peninsula, and of Northern Africa was emerging from the sea, reducing the range of the equatorial current, and thus confining the course of the currents much as they are at the present time. This would thus cause a limitation in the range of the species formerly having the greatest distribution, and extend that of those which were more local.

If migration on land when continents were joined together, and subsequent variations after their isolation through submergence, has been the main agent in the distribution of the existing terrestrial Faunæ, we must acknowledge a similar agency to currents in the distribution of marine Faunæ; and by the submergence or rise of various portions of the continents, we shall be able, if we can trace these changes, to reconstruct within certain limits the altered courses of the main oceanic currents, and get some idea of the probable geographical

distribution at different geological epochs. The greater the bathymetrical range of littoral species, the longer will such species remain unaffected, while deep-sea species may early become isolated and remain as outliers as it were, — mementos of a former condition of currents, or even of a previous geological period. The careful analysis of the Fauna of a given point, its comparison with other Faunæ, and accurate bathymetrical data, would go far towards reconstructing the Natural History of the sea in former ages, and showing its relation to the present and past times.

The representative species of Echini, Echinocardium, Psammechinus, Schizaster, in the Arctic and Antarctic boreal zones would be considered as the living representatives of a cosmopolitan Fauna existing at the time when the great equatorial current flowed unbroken round the globe, sending branches north and south along Eastern North and South America, along Eastern Japan and Australia, and the eastern coast of Africa; while the tropical species of the genera Diadema, Clypeaster, Echinoneus, Echinolampas, &c., existing at that time, had a more limited equatorial geographical distribution. The subsequent period of isolation of Atlantic and Pacific currents is shown by the existence of truly Atlantic and Pacific species; while as we go down in depth we go back also in time, and find at first representatives of the genera found in our Tertiaries, while at greater depth the species are representatives of genera found in the Cretaceous. A more detailed comparison than can be given here of the Caribbean Fauna, with the fossils of the tertiary and cretaceous deposits of our coasts, would be most interesting; but unfortunately the materials thus far collected are too fragmentary, and we must await a careful geological survey, accompanied by deep dredgings of a considerable extent of coast, before we shall have the data needed to follow up the important results to be gained in this way for palæontology and geography, of which our present incomplete materials give us such an interesting glimpse.

IV. *List of the Star-fishes.*

Asterina minuta Gray, Synopsis; Ann. Mag. Vol. VI, 1841

Syn. Asteriscus brasiliensis Lütk., Vidensk. Medd. 1859.
" stellifer Möb., Neue Seesterne.

Littoral, to 7 fathoms.

Pteraster militaris M. T., Syst. d. Asteriden.

From 120 to 125 fathoms.

Pentaceros gigas Ag.

Syn. Pentaceros grandis, reticulatus, gibbus Gray, Synops.
Oreaster reticulatus, O. aculeatus, M. T., Syst.
Oreaster gigas Lütk.

Littoral, to 128 fathoms.

Astropecten antillensis Lütk.

Littoral, to 147 fathoms.

Astropecten articulatus Lütk., Vidensk Med. 1864.

Syn. Asterias articulata Say., Journ. Acad. Nat. Sciences, Phila. 1825.

Littoral, to 5 to 6 fathoms.

Astropecten variabilis Lütk.

Littoral, to 7 fathoms.

I have thus far only met with three species of Astropecten from Florida and the West Indies, though as many as six or seven nominal species are known. The names of Lütken are given for want of authentic specimens of the others.

Luidia clathrata Lütk.

Littoral, to 101 fathoms.

Luidia alternata Lütk.

40 fathoms.

Ophidiaster (Linckia Lütk.) **ornithopus** Val.

Syn. O. ornithopus M. T., Syst. d. Ast.
" " Lütk.

Littoral, to 26 fathoms.

Ophidiaster flaccidus Lütk.

Littoral, to 123 fathoms.

Othilia spinosa Gray, Synops.

Syn. Echinaster spinosus M. T., Syst.
Littoral, to 6 fathoms.

Othilia braziliensis Ag.

Syn. Echinaster braziliensis M. T., Syst.
Littoral, to 5 or 6 fathoms.

Asteracanthion mexicanum Lütk.

From 80 to 120 fathoms.

Asteracanthion tenuispinum Lütk.

Syn. Asterias tenuispina Lam.
Asterias atlantica Ver., Trans. Con. Ac.
From 120 to 174 fathoms.

With the exception of the Pteraster and Asteracanthion tenuispinum, the bathymetrical and geographical distribution of the Star-fishes does not show any striking features. The presence of a northern and of a Mediterranean species in Florida is fully in accordance with the results derived from other classes; as with Echini and Ophiurans, we find the young in much deeper water than the adults. This is particularly well shown in a series of Pentaceros gigas; the smallest specimens (Pteraster-like in shape) are from 128 fathoms, more advanced stages (Goniodiscus-like) are from 68 fathoms, a still more advanced stage from 42 fathoms. The same is the case with Luidia clathrata and Astropecten antillensis.

Cambridge, October, 1869.